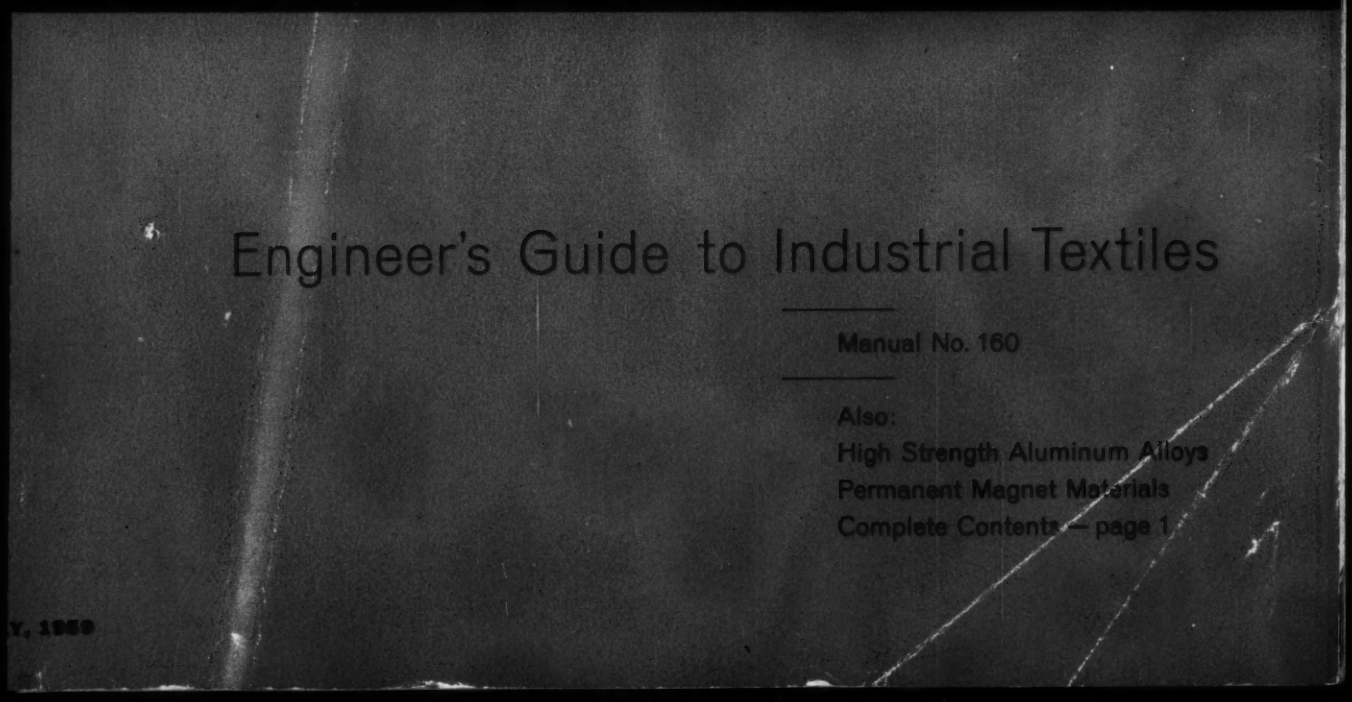
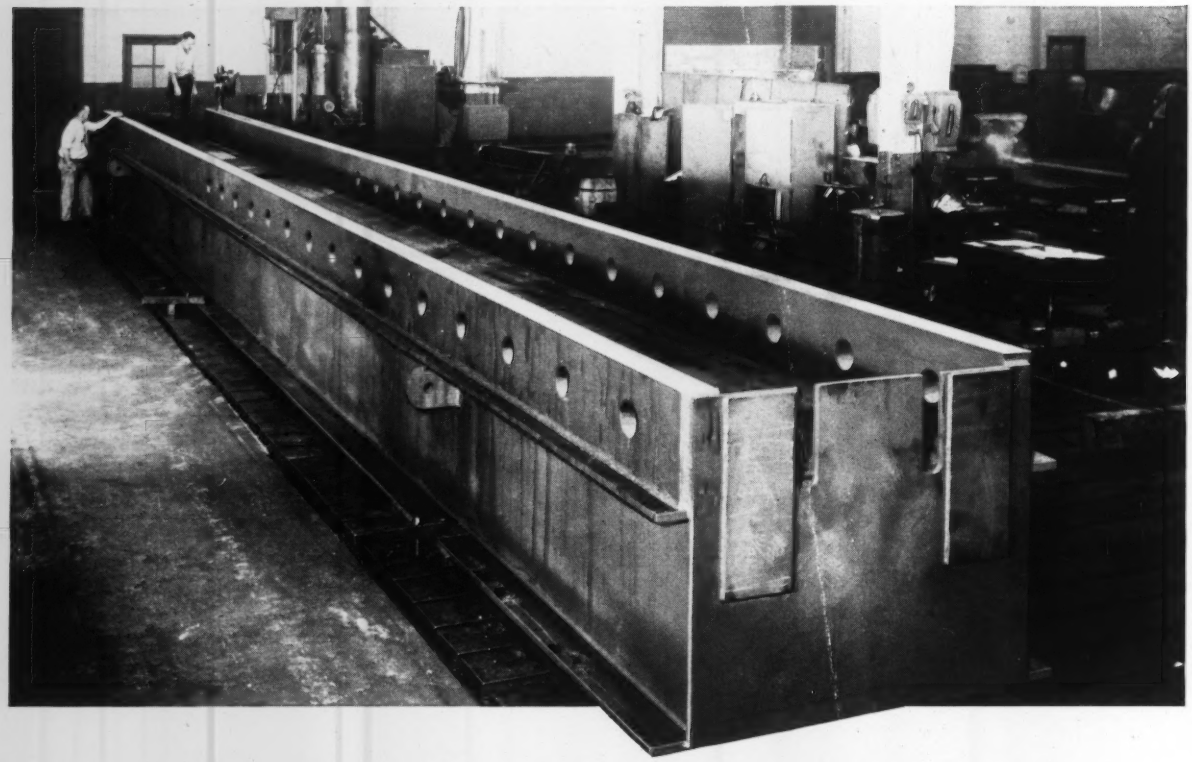
Materials in Design Engineering

FORMERLY
MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES



STEEL-WELD FABRICATION . . .



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Materials
in Design Engineering, *formerly Materials & Methods*

Selection & use of metals, nonmetallics, forms, finishes

JULY 1959
VOL. 50, NO. 1

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Conquest of the Thought Barrier

Over the years, we have been hearing of many "barriers" in science . . . the sound barrier, the water barrier, the thermal barrier.

Of all the barriers, the hardest one to break through has always been the thought barrier. Every one of these "barriers" has been conquered by men to whom the word, impossible, means only: "hasn't been done, *yet*."

The sound barrier is a shattered concept, as discredited as the phlogistic theory.

Don Campbell's *Bluebird* stopped all talk of the water barrier.

The heat of air friction against the metal "skin" of an airplane was supposed to create a heat barrier at Mach 3. Materials now in production can safely withstand the much higher temperatures involved in flight at Mach 5.

Today the thermal barrier is being called the "thermal thicket"—evidence in itself that no barrier exists.

An interesting point that all of these "barriers" have in common: each was conquered with the help of nickel-containing alloys.

This is not surprising when you stop to consider how many useful properties and combinations of properties are offered by the various nickel alloys:

Corrosion resistance to a wide variety of solids, liquids and gases . . . strength at high temperatures . . . toughness at sub-zero temperatures . . . unusual electrical properties . . . ability to protect product purity . . . spring properties . . .

When you are faced with a metal problem, investigate Nickel and its alloys. There is a good chance some nickel-containing alloy will help you break through what others consider a thought barrier.

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What's new IN MATERIALS

...AT A GLANCE

A noninflammable plastic called polytrichloropropene has been developed and is now under evaluation. Parts molded of the plastic are also said to retain form stability in boiling water. The new plastic was made possible by the development of a highly chlorinated monomer that can be copolymerized with common plastics such as polyethylene and polyvinylacetate, adding to these polymers the property of flame resistance.

Source: Stanford Research Institute, Menlo Park, Calif. and Ethyl Corp., 100 Park Ave., New York 17.

A die castable magnesium alloy for use above 500 F has been developed. It contains 1% thorium, 1% manganese, balance magnesium. Test bars of the new alloy had a tensile strength of 30,200 psi at 70 F, 16,800 at 400 F, 12,400 at 600 F and 7800 at 800 F. According to the developer, the alloy can be die cast in regular equipment with a minimum of change from regular procedure.

Source: Dow Chemical Co., Midland, Mich.

Strong, ductile steel strip rolled from powder will be available in five to six years, a major steel producer predicts. The 2-in. strip made in the laboratory is claimed to meet all standard property specifications for steel of equivalent carbon content, and it also passes a stringent formability test. Metallurgical structure appears to be the same as that of conventional strip. Although bypassing the melting step will save a lot of money for the producer, it is not expected that such savings will be reflected in the price of the strip.

Source: Peter Robertson, Vice President for Research and Planning, Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio.

Dense, nonporous coatings of chromium, molybdenum and tungsten can be applied to metallic and nonmetallic materials by using a modified vapor phase deposition method now in the developmental stage. Coatings applied by the process do not crack, spall or flake after extensive deformation, and withstand temperatures well above 300 F. Tests show that the coatings give complete protection to base materials after 64-hr immersion in 20% nitric acid. (More details in a forthcoming issue.)

Source: Alloyd Research Corp., 203 Arsenal St., Watertown 72, Mass.

A manganese wrought iron, supplied in the form of plate and pipe, is said to have excellent impact resistance at sub-zero temperatures. Tests performed on Charpy V-notch specimens show that the new wrought iron has a mean energy absorption of 15 ft-lb at —58 F. According to the developer, the wrought iron has corrosion resistance properties comparable to those of grade 4-D (see M/DE, Feb '59, p 100). The wrought iron is easy to weld and can be formed either hot or cold.

Source: A. M. Byers Co., Clark Bldg., P. O. Box 1076, Pittsburgh 30.

Longer lasting chromium-plated automobile trim may result from the development of a new plating process that applies thick, two-layer chromium electroplates to metal parts. The initial deposit is a bright, crack-free chromium for optimum

coverage and buildup in low current density areas; the second layer a bright deposit of finely cracked chromium. Accelerated laboratory tests show that the new electroplate increases corrosion resistance of automobile trim by 500% over that achieved with conventional chromium electroplates.
Source: Metal & Thermit Corp., 1700 E. Nine Mile Rd., Ferndale, Detroit 20.

Polypropylene rubber, introduced last summer (M/DE, July '58, p 4), is now in semicommercial production in Italy. The cured elastomer has 4000 psi tensile strength, 500% elongation and 1700 psi stress at 300% elongation. The new synthetic rubber is said to have outstanding resistance to heat, oxygen, ozone, and other aging and degrading agents. (More details next month.)
Source: Chemore Corp., 2 Broadway, New York 4.

A high strength aluminum casting alloy has been developed by varying the chemical composition of conventional A-356 alloy. Mechanical properties in the T6 condition are 45,000 psi tensile strength, 35,000 psi yield strength and 3% elongation. The alloy shows promise for sand and permanent mold castings used in missiles and jets.
Source: Rolle Mfg. Co., 3rd & Cannon Aves., Lansdale, Pa.

A nylon screw with a metal core is said to combine the insulating properties of plastics with the strength of steel. The screw, now available in a variety of types and sizes, has high torque strength, good shock absorbing properties and good resistance to vibration.
Source: Austin Screw Products Co., 4873 W. Armitage Ave., Chicago 39.

Trends in the metals industry indicate a reduction in carbon content of low alloy steels from about 0.45 to 0.25-0.35% to improve fabricability. The required strength of these steels will be obtained by improved heat treatment, particularly by improved quenching methods. Other trends: increased use of nodular (ductile) iron, and increased use of welding in fabricating metal parts.

Thick, nonporous, ductile aluminum coatings protect ferrous and nonferrous metals against corrosion without danger of hydrogen embrittlement. Coatings are applied by a technique that is related in principle to the vacuum metallizing process. Pure aluminum coatings applied by the method average about 0.004 in. thick, compared to 0.000001 in. for vacuum metallized coatings.
Source: NRC Equipment Corp., 160 Charlemont St., Newton Highlands 61, Mass.

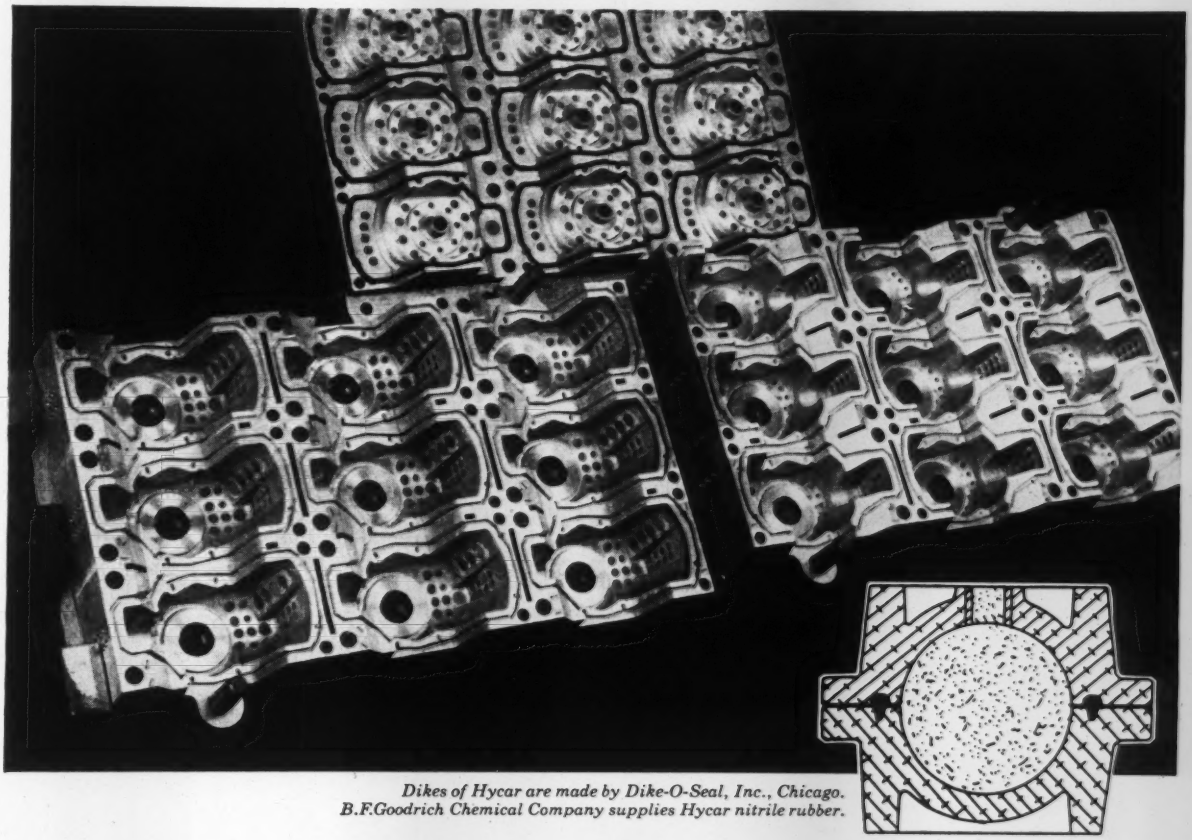
A new method uses infrared to melt and heat treat metals. The method, details of which have not been revealed, operates over the temperature range 300 to 2600 F. It has potential use for melting aluminum and for heat treating superalloys.
Source: A. F. Holden Co., 11300M Schaefer Hwy., Detroit 27.

Two oxidation resistant columbium-base alloys have been hot extruded into bars directly from an ingot melted by the consumable electrode vacuum casting process. Previously, columbium had to be protected with an oxidation resistant coating before hot extruding. Limited property data indicate the new alloys have 40,000 psi tensile strength at 2400 F.
Source: Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17.

Turn to page 135 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



Dikes of Hycar are made by Dike-O-Seal, Inc., Chicago.
B.F.Goodrich Chemical Company supplies Hycar nitrile rubber.

Hycar seals go to core of pressing foundry problem

Modern foundry practice calls for cutting costs by blowing sand into core boxes under pressure. The result is a better core and eventually a better casting—but there are problems. Without a perfect seal, operators get a condition called "blow-by", an erosion of core boxes that may result in flaws in the finished casting—as well as damaging the box itself.

The problem is being solved with flexible Dikes made from Hycar nitrile rubber. These Dikes provide a perfect seal under some tough operating conditions. The Dikes have to be flexible to fit the outlines of complicated core box parting faces. And they stay in place during core box cleaning, exposing them to live steam, alkali or even fuel oil.

Since Hycar retains its resilience under a wide range of temperature and the most severe mechanical deformation, it proved ideal. In addition, it has unusual abrasion resistance and can withstand hydrocarbons and chemicals that destroy ordinary rubber. Hycar may be the material that can help you get more results for your product. For information, write Dept. CL-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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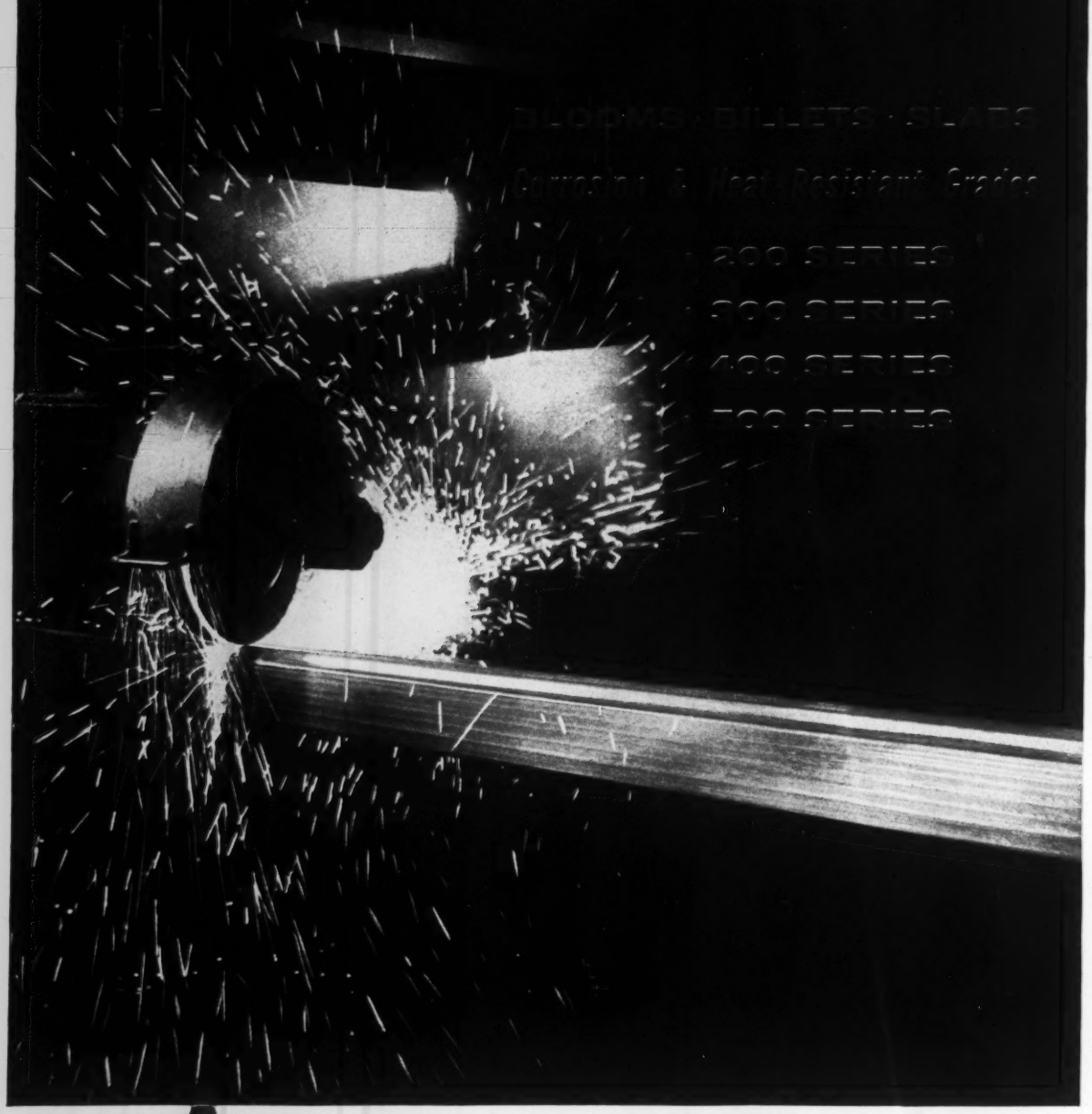

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MATERIALS AT WORK

...AT A GLANCE

Armored vehicles now made of aluminum

Aluminum armor plate is now being used by the Army for combat vehicles and floating trucks. The primary advantage of the switch from steel to aluminum is lighter weight (and thus better economy, maneuverability and transportability). However, the aluminum plate is also said to provide equivalent ballistic protection. In addition, aluminum offers excellent strength-weight ratio, good corrosion resistance and low cost forming and welding. One of the new floating trucks weighs less when fully loaded than an empty steel truck.

Source: Reynolds Metals Co.; truck built for the Army by Food Machinery & Chemical Corp.

PVC tubing outlasts carbon steel

The switch from carbon steel to rigid polyvinyl chloride is said to have eliminated yearly replacement of corroded tubing used to handle brine solution in a ham and bacon curing operation. Polyvinyl chloride was selected because it is less expensive than steel, is easier to install, and requires no maintenance. The tubing, which measures ½-3 in. in dia, must withstand temperatures of 95-105 F and pressures up to 90 psi.

Source: Tube Turns Plastics, Inc.; used by Patrick Cudahy, Inc.

Stainless housing for nuclear battery

Ease of fabrication, resistance to corrosion, commercial availability at low cost, and the ability to be given a pressure-tight braze are the reasons given for the selection of 302 stainless for the outer shell of a new nuclear battery. The stainless case, which houses krypton-85 under more than 140 psi, measures about 1 in. high and ⅓ in. in dia, and has a 0.050-in. wall which is held within ± 0.003 in. Molybdenum, nickel and nickel alloys were also considered, but only stainless satisfied all requirements.

Source: Committee of Stainless Steel Producers; battery made by Radiation Research Corp.

Radar traffic regulator uses reinforced plastics

Glass-reinforced polyester is now being used to house radar vehicle detectors. The detectors, mounted about 16 ft over the roadway, pick up impulses from passing vehicles and transmit information to computing circuits which regulate traffic signals for most efficient traffic flow. Glass-polyester was selected because of its excellent weather resistance, good insulation properties, and high strength at low weight. The unit measures 11½ in. in dia and weighs about 16 lb.

Source: National Vulcanized Fibre Co.; unit manufactured by Automatic Signal Div., Eastern Industries.

Foams make jet ejection seats comfortable

Combining two different types of urethane foam, Navy jet plane ejection seats are not only extremely safe but comfortable as well. The seats consist of a 4-in. cushion of flexible urethane foam laminated to a 2-in. layer of semirigid foam. During ejection, the semirigid foam partially collapses (as a result

(continued on p 9)

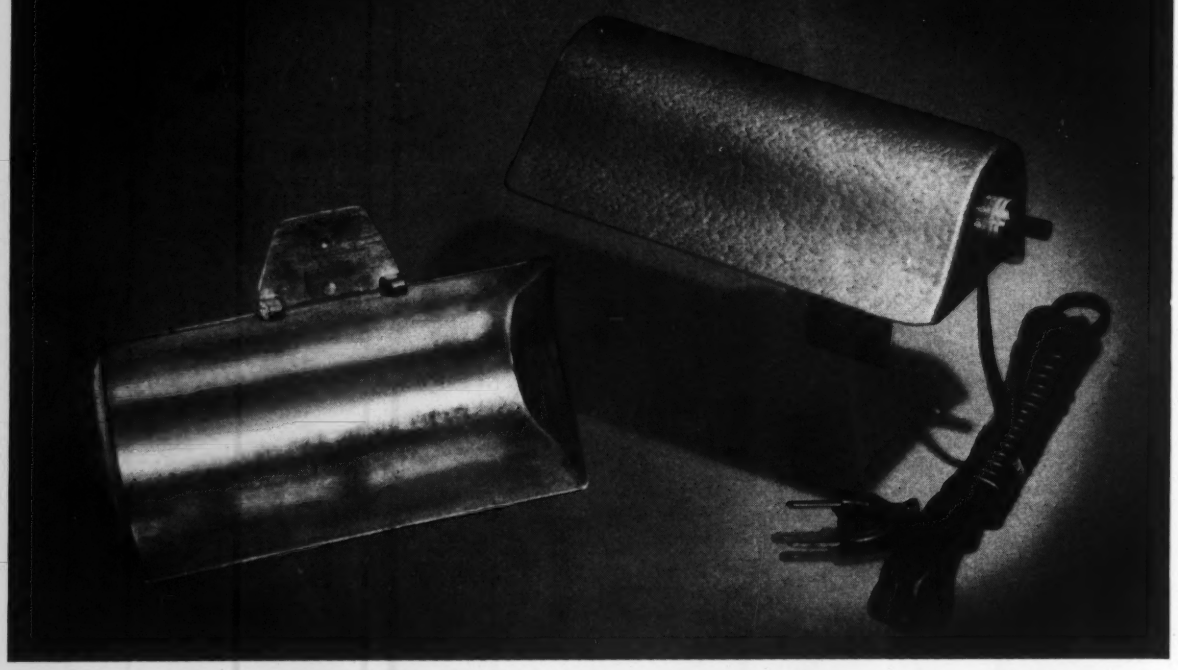
Briefs

Nylon bearings are the key to the smooth operation of Chrysler Corp.'s new swivel seats. To enter the auto, the passenger seats himself with his legs outside the car, then lifts his feet and swivels the seat into locked position.

Welded steel rails are now being installed by the Great Northern Railroad. The rails, which are said to eliminate the familiar "clickety-clack" caused by bolted rails, are welded in ¼-mile lengths and transported over 1000 miles to the installation site.

Jet-propelled babies will rest more comfortably in cradles now being used by some airlines. The cradles, which attach to bulkheads with special steel fittings, weigh less than 5 lb and consist of nylon upholstery, Dacron crepe sheets and safety belts, and magnesium and aluminum frames. When not in use, the cradles fold to 16 x 35 x 2½ in. thick.

IT'S LIGHTER THAN YOU THINK!



AND EASY TO ASSEMBLE WHEN DIE CAST WITH... ZAMAK

The shade for this new KLIP-LITE* music stand is made of a single thin-wall zinc die casting—for light weight and low-cost assembly. As thin as a stamping but with far greater rigidity, the contours could not be duplicated in sheet metal.

By designing for die casting, only 4 holes are needed before spray finishing and assembling the socket-switch and mounting bracket.

These extremely thin wall sections—possible only with ZINC die castings—minimize weight and are stronger in proportion to thickness than heavier sections.

Parts designed for ZAMAK alloy die casting will meet competition of either stampings or aluminum castings—and at lower cost.

*Made by WIESE MANUFACTURING COMPANY—Davenport, Iowa.

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of an explosive discharge) and absorbs most of the shock. The 4-in. flexible cushion absorbs the residual shock by compressing and then returns to normal, thus transforming instantaneous shock into gradual acceleration.
Source: Dayton Rubber Co.

Ceramic-stainless connector withstands 1200 F

An electrical connector which maintains excellent electrical insulation and a hermetic seal at temperatures ranging from –400 to 1200 F is made of stainless steel chemically bonded to a boron-free ceramic material. The unit is said to be especially useful in nuclear environments.
Source: Technical Industries Corp.

Alloy steel spouts replace carbon steel

The change from carbon steel to Jalloy-280 (an abrasive resistant alloy steel) has eliminated expensive maintenance on spouts used in the processing of highly abrasive soy beans. The spouts, which are 8 in. in dia and as long as 48 ft, carry hot soy beans through various processing stages. When made of carbon steel, the spouts had to be replaced every few months. The Jalloy spouts are said to last several years.
Source: Jones & Laughlin Steel Corp.; spouts used by Townsends, Inc.

Acrylic paint protects power equipment

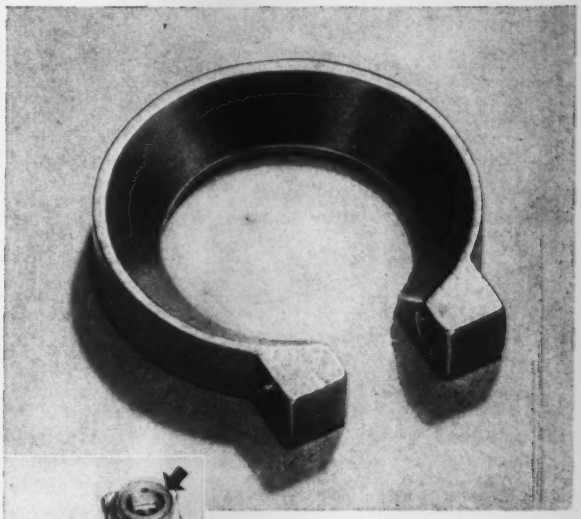
Acrylic paint is now being used to protect outdoor high voltage circuit breakers and other switchgear equipment. The paint, which is similar to that used on new automobiles, is said to be "far superior" to the alkyd paint previously used because it offers greater resistance to acid and alkali impurities in the air. The acrylic paint is expected to last about twice as long.
Source: General Electric Co.

Steel antenna has 4-billion-mile range

About 200 tons of steel were used in a massive, dish-like tracking antenna built for the Army to gather scientific information from outer space. The antenna, which measures 110 ft in height and 85 ft in dia, has a tracking range of 400,000 miles. By 1960, however, the range is expected to increase to 40 million miles and by 1962, to 4 billion miles. (Increased range will result from improved efficiency of the antenna and increased power and size of space vehicle radio transmitters.)
Source: Blaw-Knox Co.; used by the National Aeronautics and Space Agency.

(more Materials at Work on next page)

ADVANTAGES SUCH AS THESE
with **METAL POWDERS**



provide parts that serve dual purposes

This NICKEL SILVER metal powder part does *two* jobs: (1) locks the end cylinder and (2) provides vertical tension for the SIGMA Series 72 Polar Relay. These complicated devices must be accurate, compact and dependable for instrumentation, computers, telegraphy, controls, and alarm systems.

Making this part by any method, other than powder metallurgy, would be difficult and expensive. Giving the job to a custom fabricator*, SIGMA INSTRUMENTS found that design and strength requirements of this critical part could be provided at a reasonable cost—uniformly accurate and ready for assembly.

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Edited by
Walter Lubars

Six case histories show how . . .

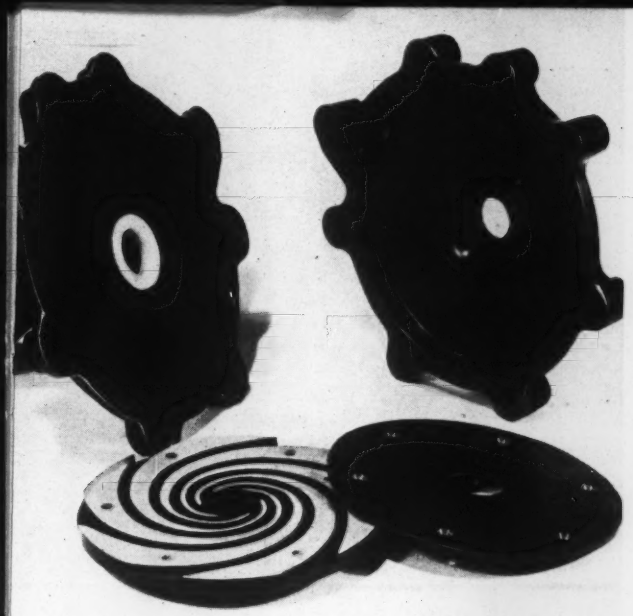
Premix plastics moldings cut costs, improve design

Premix polyester plastics moldings are becoming increasingly popular because they offer: fast, low cost production of complex parts; elimination of many assembly and finishing operations; good electrical insulation; good chemical and heat resistance; light weight; low water absorption; and ability to hold close tolerances. The accompanying case histories illustrate many of these advantages. (For more detailed data on premix plastics moldings see MATERIALS & METHODS, Sept '55, p 104.)

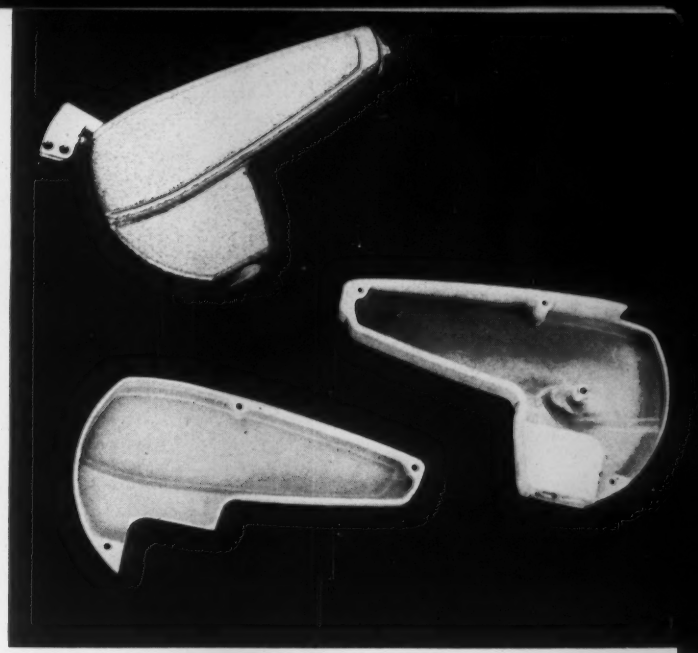
(This article is based on a paper delivered by William T. Scott, Atlas Powder Co., at the recent meeting of the Reinforced Plastics Div., Society of the Plastics Industry, Inc.)

Indicator housing used on automobile instrument panel (Chevrolet Div., General Motors Corp.). *Original material:* zinc die casting; *new material:* glass fiber-reinforced polyester premix (George Morrell Corp.); *advantages gained:* reduced costs; considerably higher color reflection.

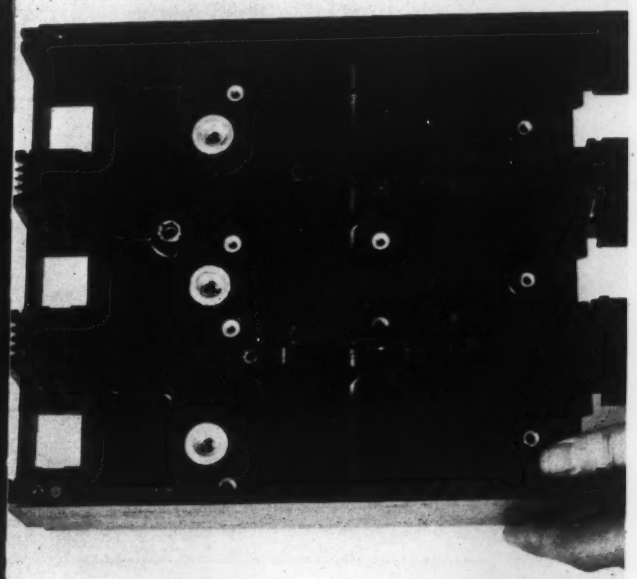
Housing and distributor duct for automobile heater system (Chrysler Corp.). *Original material:* welded steel stampings; *new material:* sisal-reinforced polyester premix (Woodall Industries, Inc.); *advantages gained:* tooling cost reduction of $250,000; elimination of welding and painting; better thermal insulation.



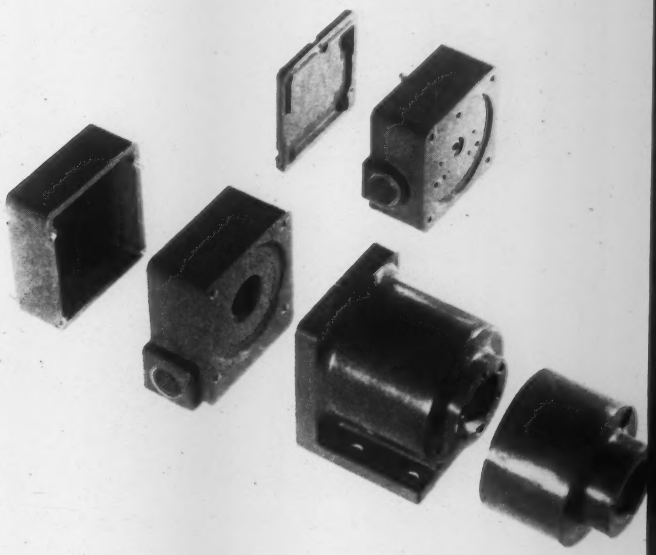
Centrifugal pump used in agricultural chemical sprayers (John Bean Div., Food Machinery & Chemical Corp.). *Original material:* pump is new design—however, aluminum die castings were considered; *new material:* glass fiber-reinforced polyester premix (Atlas Powder Co.); *advantages gained:* mold cost reduction of 60%; superior chemical and abrasion resistance; greatly simplified assembly.



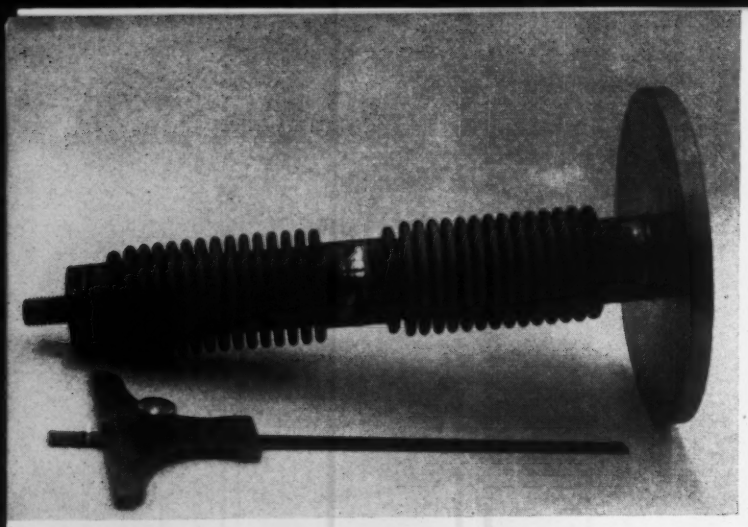
Surgical lamp housing used to hold a device which facilitates lamp adjustment (Wilmot Castle Co.). *Original material:* aluminum die castings; *new material:* glass fiber-reinforced polyester premix; *advantages gained:* ability to hold close tolerances without machining; elimination of reworking, buffing, etc.; ability to have a steel insert molded in; ease of painting.



Circuit breaker base used to hold operating components in heavy duty equipment (Westinghouse Electric Corp.). *Original material:* molded phenolic; *new material:* glass fiber-reinforced polyester premix (Micarta Div., Westinghouse); *advantages gained:* improved strength; higher arc resistance; better flame resistance; decreased water absorption; ability to hold tolerances of ±0.003 in.



Speed control housing used to contain a device which regulates speed of overhead cranes and other heavy equipment (Euclid Electric & Mfg. Co.). *Original material:* metal castings with snap-on metal covers; *new material:* glass fiber-reinforced polyester premix (Carl Zehr Co.); *advantages gained:* reduced size and weight; faster production; reduced mold cost; greater flexibility of design; high strength; excellent resistance to corrosive atmospheres.

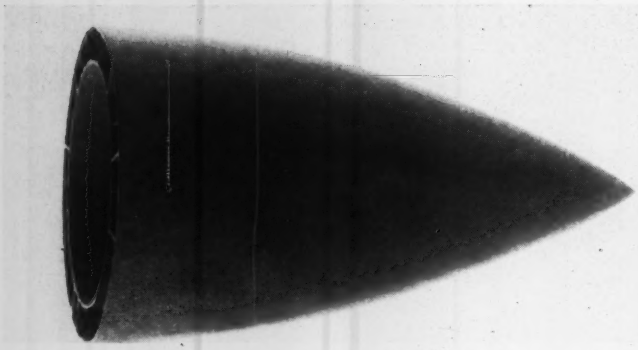


Seamless titanium bellows used in reactor valve

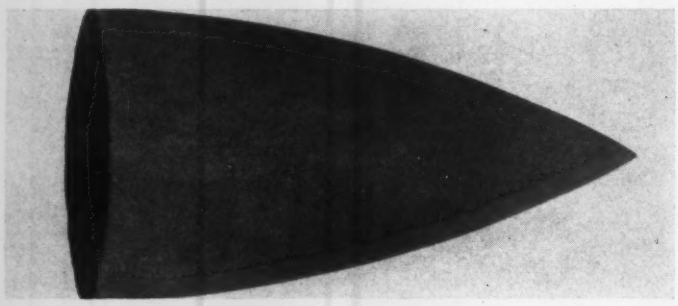
Shown in the photo at left is what is said to be the first packless valve stem assembly made with seamless titanium bellows.

The bellows, which have a 1¼-in. o.d., are used in an all-titanium primary reactor loop designed to carry highly corrosive solutions at 570 F and 2500 psig. According to Robertshaw Fulton Controls Co., titanium was selected (in spite of the fact that its low elongation properties make forming difficult) because it was the only material which satisfied all requirements. Gold plated bellows were also tried, but proved unsatisfactory.

Ceramic honeycomb for missiles and aircraft

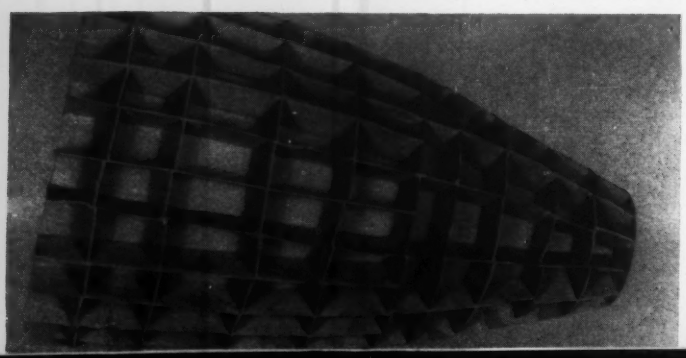


Ceramic honeycomb nose cone consists of . . .



. . . formed outer ceramic skin and . . .

. . . formed ceramic honeycomb core.



Ceramic honeycomb structures are replacing reinforced plastics for some nose cones, radomes and antenna windows in high speed aircraft and missiles, according to Boeing Airplane Co.

The switch is necessary where reinforced plastics no longer satisfies demands of high speed flight. Aerodynamic heating at today's increased speeds robs reinforced plastics of its structural integrity and reduces its resistance to rain erosion.

Although ceramic materials have been considered the logical replacement for some time (solid ceramic antenna coverings, radomes and nose cones have already been successfully used on small air-to-air and ground-to-air missiles), the problems of weight, producibility and poor electronic characteristics had to be overcome before they could be used more extensively.

Recently developed techniques for producing ceramic honeycomb sandwich structures are solving these problems. According to

(continued on p 179)

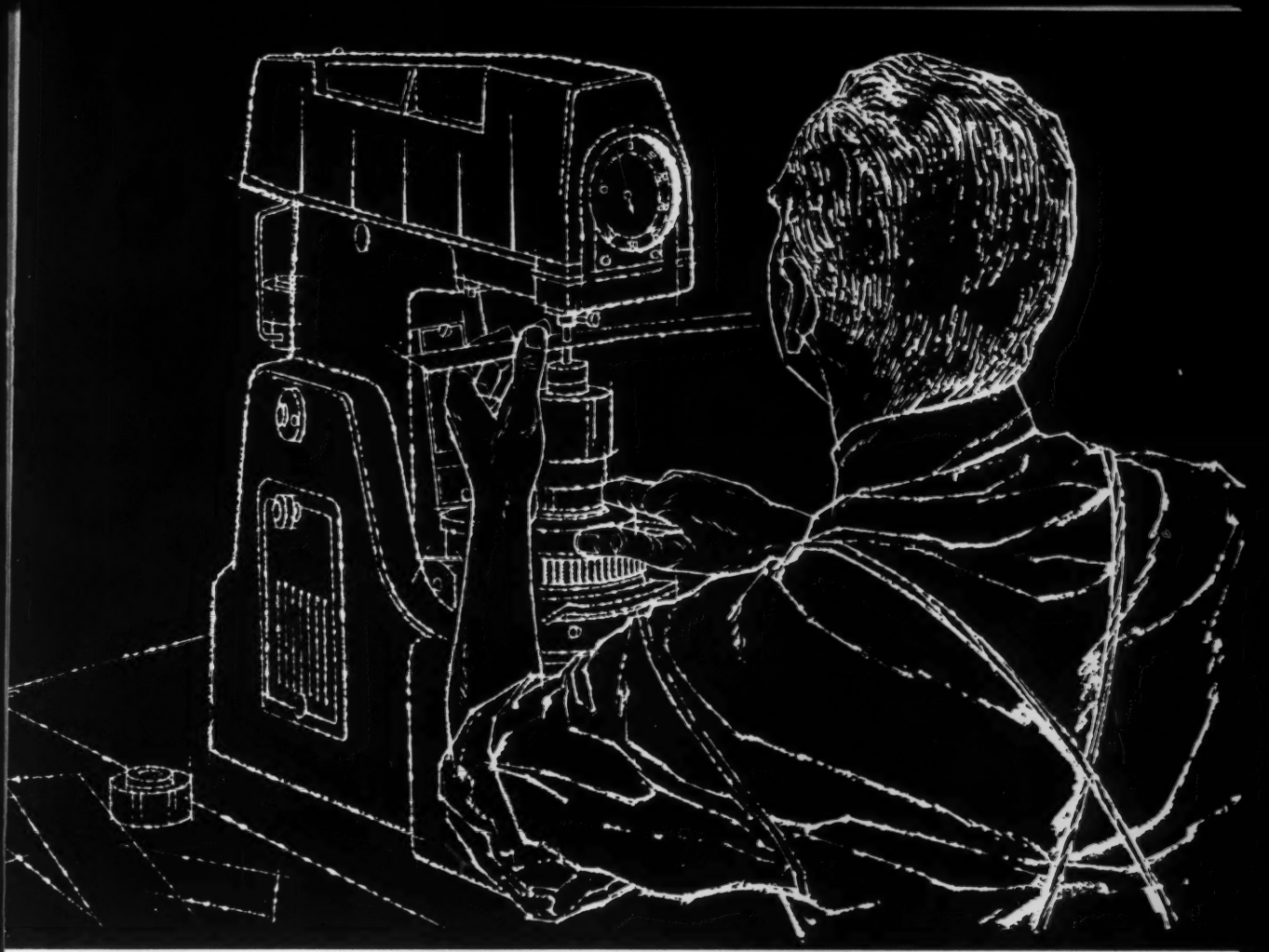
MORE MATERIALS AT WORK

Metal powder tools reduce vibration 179

Largest aluminum ring..... 180

Epoxy-backed electro reduces weight 70%..... 182

Seven die castings key to unit's low cost..... 186



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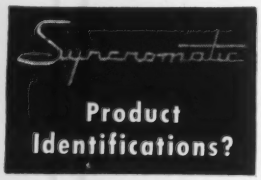

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Best use of materials

To the Editor:

The idea of your Annual Awards Competition is without doubt a constructive, honest and effective way to help the progress of technological activity. I was going to submit three entries but decided to substitute this letter for them. I made this decision because I thought each of my entries would be the best use of materials for the particular design involved. Every participant must expect to win for the same reason. If the best use of materials is to be influenced by the volume, quality, cost, importance and use of the product, then injustice will be done to some entries.

To restrict oneself to considering the relative uses of the thousands of materials available to solve our problems will not be proper. What may seem to be the best material for a design at this moment may be only an alternate material within a short period of time. This proves that we are dealing with particulars. But what is important is the universal. In this case the universal is "knowledge of materials." The more that becomes known about materials properties and characteristics, the more will best uses be realized day after day. What we need is knowledge, or search for knowledge, of materials.

In my opinion the practice of continuing to learn about materials after graduation is a practice which will create more best uses of materials in product design than anything else.

GEORGE SITARAS
Industrial Engineer
Otis Elevator Co.
New York, N. Y.

We cannot quarrel with the importance of greater knowledge of materials. We feel compelled to point out, however, that nowhere have we—or the judges—indicated that the volume, quality, cost, importance or use of the product is a factor influencing the selection of the winning entries in the M/DE Awards Competition. Whether or not all engineers honestly believe that they have made the best possible choice at a particular time is a debatable question; the fact remains that the non-winning entrants in the Competition failed to convince the judges that they had followed a rigorous, logical procedure in arriving at their decision.

Machinability of superalloys

To the Editor:

Our department is starting a comprehensive study that should be of interest to your readers. Because of this, we are asking for any available assistance.

The project is to establish a machinability index for Discalloy 24, René 41, Waspaloy, Inconel 700, Udimet 500 and other new superalloys. The evalua-

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tion will include dynamometer tests on metal removal, feeds and speeds for optimum finish and tool life, coolants, cutting tools and grinding wheels.

The report will be constructed so that new material can be added as it becomes available. All contributors will receive full credit and a copy of the report.

R. H. PATCHEN
Production Engineer
Aerojet-General Corp.
Azusa, Calif.

'Hard = brittle': a fallacy

To the Editor:

In your January issue, Mr. Thackrey asks for an explanation of the "hard-equals-brittle" concept of metal properties and mentions modulus of elasticity as related to brittleness. Actually brittleness has nothing to do with elasticity since it is purely a measure of plasticity. Brittleness is normally measured in terms of percent elongation. Elastic elongation does not enter the calculation since this elongation is not present when the test bar is measured.

Brittleness, then, is the inability of a material to plastically deform. Since plastic deformation involves the movement of planes of atoms relative to each other, brittleness in a material indicates the presence of an impediment to this movement. This impediment may assume a wide variety of forms. Most common are the presence of foreign atoms and dislocations of atoms in the crystal structure of the material.

The fallacy of high strength=brittleness=high hardness can be easily illustrated. (*An extensive table of metals properties included by the writer has been omitted for space reasons—Ed.*) Gold has about the same tensile strength as gray iron, but gray iron is 100 times as brittle. Spring temper stainless has a brittleness about midway between gold and gray iron but 15 times their strength. Platinum has a modulus of elasticity near that of spring temper stainless steel, but has one-sixth its strength and double its brittleness. Hardness does not correlate with either strength or brittleness.

If we narrow our range of comparisons to include only one type of alloy, we sometimes get good correlation. For example, in most steels, strength is proportional to hardness and, to a somewhat lesser extent, to brittleness. However in cast irons we have a very different picture. Malleable iron is approximately two to three times as strong as gray iron but may be as much as 40 times more ductile. Nodular iron may be six times as strong as gray iron and ten times as ductile.

It is hoped that this discussion will point out the danger of applying general rules to a complex set of variables.

EUGENE A. STACK
Materials Engineer
Thiokol Chemical Corp.
Denville, N. J.

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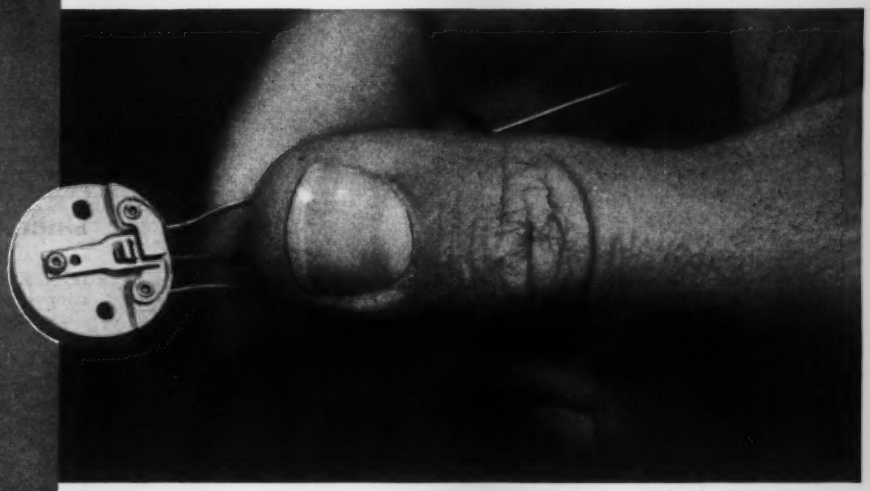

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PRICES AND SUPPLY

...AT A GLANCE

Use of nickel in 1959 may come close to the record set in 1957. According to International Nickel Co., total consumption should end up at about 385 million pounds; 1957's record consumption was 415 million pounds.

A substantial increase in steel production may result from Republic Steel Corp.'s plan to spend $375 million for "capital improvement" over the next four years. Indications are that the program may include the addition of 300,000-400,000 tons in annual capacity.

More polypropylene will be available as a result of Hercules Powder Co.'s decision to increase its production by 150%. According to Bill Ulrich, sales manager, the move was prompted by increased demand for the material in five major areas: closures and containers, industrial moldings, film, housewares and filaments—as well as many miscellaneous uses. When the expansion is complete, Hercules' capacity will be 50 million pounds per year. Mr. Ulrich predicts that by 1965 use of polypropylene in automobiles will reach about 3-5 lb per car; this year it was only 4 oz.

More stainless steel strip will be available as a result of Universal-Cyclops Steel Corp.'s new 20-million-ton-per-year plant in Coshocton, Ohio. According to the company, the new plant will more than double its strip producing capacity.

Greater availability of ultra-pure silicon will result from licenses recently granted by Westinghouse Electric Corp. to Dow Corning Corp. and Monsanto Chemical Co. According to Westinghouse, its special process produces silicon with impurities amounting to less than one part in 6 billion.

Increased quantities of better, cheaper carbon steels through more extensive use of the oxygen process is predicted by Sharon Steel Corp. According to Sharon, "We have probably seen the last large, new open hearth shop built in the United States." One of the major factors for the growing acceptance of the oxygen process is the lower initial cost: cost of oxygen steelmaking facilities is about $15 per annual ton of capacity, as compared to $18 for electric furnaces and $35 for open hearth furnaces. Other reasons for its acceptance: higher metallic yields and simplicity of operation.

Price of butyl acrylate —an important ingredient in the production of paint, textile and leather finishes, and other industrial products—was cut 10¢ per lb by Celanese Corp. of America and Union Carbide Corp. New price is 45¢ per lb.

Aluminum production has been increased to 100% of rated annual capacity by Reynolds Metals Co. Early in May, Reynolds raised its output from 89% to 93%. Industry sources ascribe the increases (by Reynolds and other aluminum producers) to hedge buying against possible strikes after July 31—the expiration date of labor contracts for most major aluminum companies.

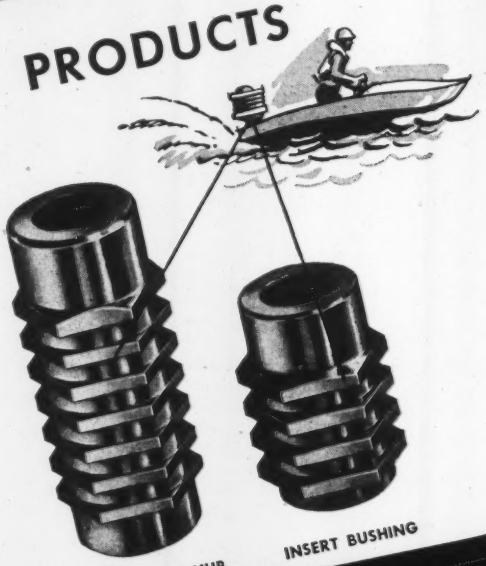
Production of lead and zinc has been decreased by American Metal Climax, Inc. In announcing the action, Jean Vuillequez, vice president, repeated a statement printed in the company's annual report for 1958: "The only lasting cure for the lead and zinc industry here and abroad is to bring supply and demand into balance." The reductions amount to 6500 short tons of lead and 6000 short tons of zinc per year.

two typical cases where MUELLER BRASS *determined the best and most*

CASE HISTORY 1750

SCREW MACHINE PRODUCTS for outboard motors

Mueller Brass Co. Methods Analysis Engineers, after careful consideration of every aspect of the job requirements, found that the best method of producing these 2 outboard motor parts at the lowest cost was as screw machine products made from hollow hex rod. The insert drive hub and insert bushing are used in the lower units of one of America's most powerful outboards and must absorb constant punishment without failing. Mueller Brass Co. has one of the world's largest automatic screw machine departments fabricating both ferrous and nonferrous custom parts. Parts can be produced in an infinite variety of shapes and sizes from 1/8" to 3 1/4" in a wide range of free cutting and specialized alloys. Complete facilities are available for all secondary and finishing operations, as well.



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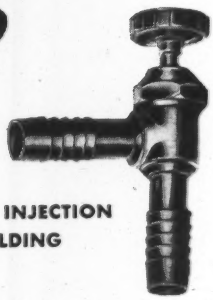

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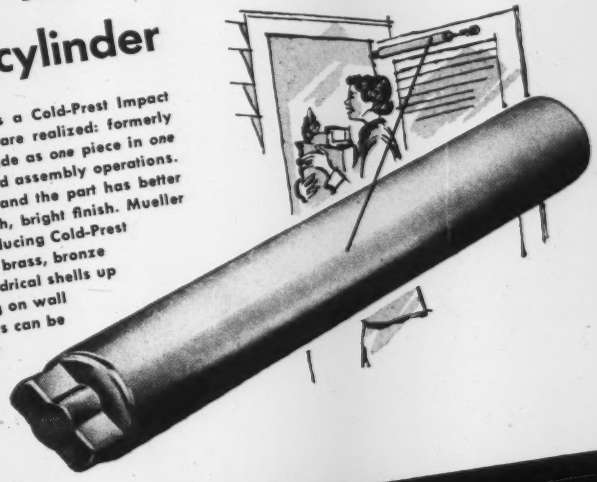
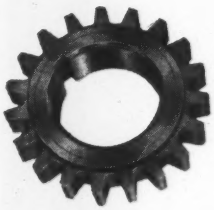
economical method of producing parts

CASE HISTORY 226

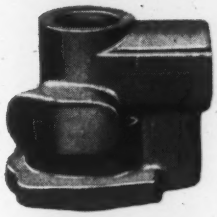
COLD-PREST® IMPACT EXTRUSION for door closer cylinder

By producing this door closer cylinder as a Cold-Prest Impact Extrusion, several important advantages are realized: formerly made in three pieces, the part is now made as one piece in one operation which eliminates machining and assembly operations. The possibility of leakage is eliminated and the part has better physical properties, as well as a smooth, bright finish. Mueller Brass Co. has complete facilities for producing Cold-Prest impact extrusions of aluminum, copper, brass, bronze and steel. Square, rectangular and cylindrical shells up to 28" in length are possible depending on wall thickness and other design details. Parts can be designed having ribs, flutes, splines or bosses . . . with multiple wall diameters and with various wall sections.

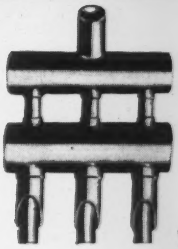




POWDERED METAL PARTS



SAND CASTINGS



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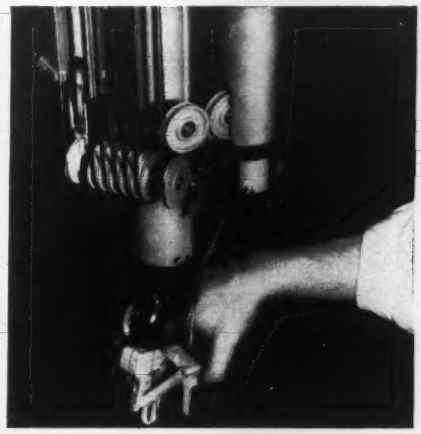
How NS solved another special steel problem

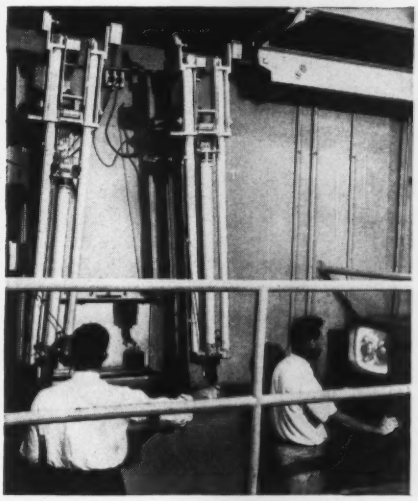
Photos courtesy of Nuclear Systems Division, The Budd Company

RADIOACTIVE MATERIAL is handled remotely by operator from behind three-foot thick lead-glass wall. Nilcor strips, which make quick, accurate system response possible, can be seen running vertically from pulleys just above operator's hands.

SPECIAL NS-ATHENIA STEEL PUTS LIFE IN ATOMIC-AGE ROBOT



HAND MOVEMENTS at operator end of master-slave system are translated without distortion, or time lag through seven Nilcor strips (shown in photo) that travel through 15-foot belt and pulley system.



OPERATOR STATION, shielded by protective wall, has television monitor screen where action inside radioactive room is reproduced as operator manipulates controls of master-slave system.

To manipulate radioactive materials with lifelike dexterity, from the other side of a three-foot thick protective wall, requires robot controls with a high degree of precision and quick response.

Ordinary cable or belt arrangements gave too much stretch between the operator's "master" hand movements and the identical "slave" movement at the other end of the system. Movements had to be translated almost instantaneously and duplicated exactly at the slave end of the system. To help solve this problem, robot system manufacturers came to the Athenia Steel Division of National-Standard to find a strip material that would serve in the belt-and-pulley arrangement of the mechanism with minimum stretch and friction and without backlashing or overshooting.

NATIONAL-STANDARD ENGINEERS at Athenia in Clifton, N. J., recommended Nilcor* strip (basically a cobalt-chromium-nickel alloy) because of its high fatigue resistance, high tensile strength and exceptionally high corrosion resistance—plus less than ⅛-inch lateral sweep per 8-foot length when laying flat without tension. Experiments with .005 Nilcor strip in the robot systems showed an 80% reduction in stretch and 90% reduction in friction over standard wire materials.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring specialty steel and wire to meet unique applications, is available to *you* from National-Standard. For the many thousands of applications where only specialty steel or wire will solve the problem, let National-Standard engineers go to work for you. Write for additional information to National-Standard Company, Niles, Michigan.

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DIVISIONS: NATIONAL-STANDARD, Niles, Mich.; tire wire, stainless, music spring and plated wires • **WORCESTER WIRE WORKS**, Worcester, Mass.; high and low carbon specialty wires • **WAGNER LITHO MACHINERY**, Secaucus, N. J.; metal decorating equipment • **ATHENIA STEEL**, Clifton, N. J.; flat, high-carbon spring steels • **REYNOLDS WIRE**, Dixon, Ill.; industrial wire cloth • **CROSS PERFORATED METALS**, Carbondale, Pa.; decorative, commercial, and industrial perforated metals.

For more information, turn to Reader Service card, circle No. 375

DOW | PLASTICS PLAY LEAD IN NEW SALES SEASON

Rapid-fire developments in versatile thermoplastic materials herald sure-fire successes on the sales front. As the new products make their public debut, plastics are increasingly conspicuous by their presence. These chemically engineered materials are lightweight, yet strong and durable. They save pennies on the production line, look like a million in the show window.

Take Verelite*, newest in the fast growing Dow lineup of polystyrene materials. Designed specially for interior lighting applications such as grids and diffusers for fluorescent fixtures, it is light stabilized offering superior resistance to yellowing. It is now available in several different granulations for both extrusion and molding.

*TRADEMARK

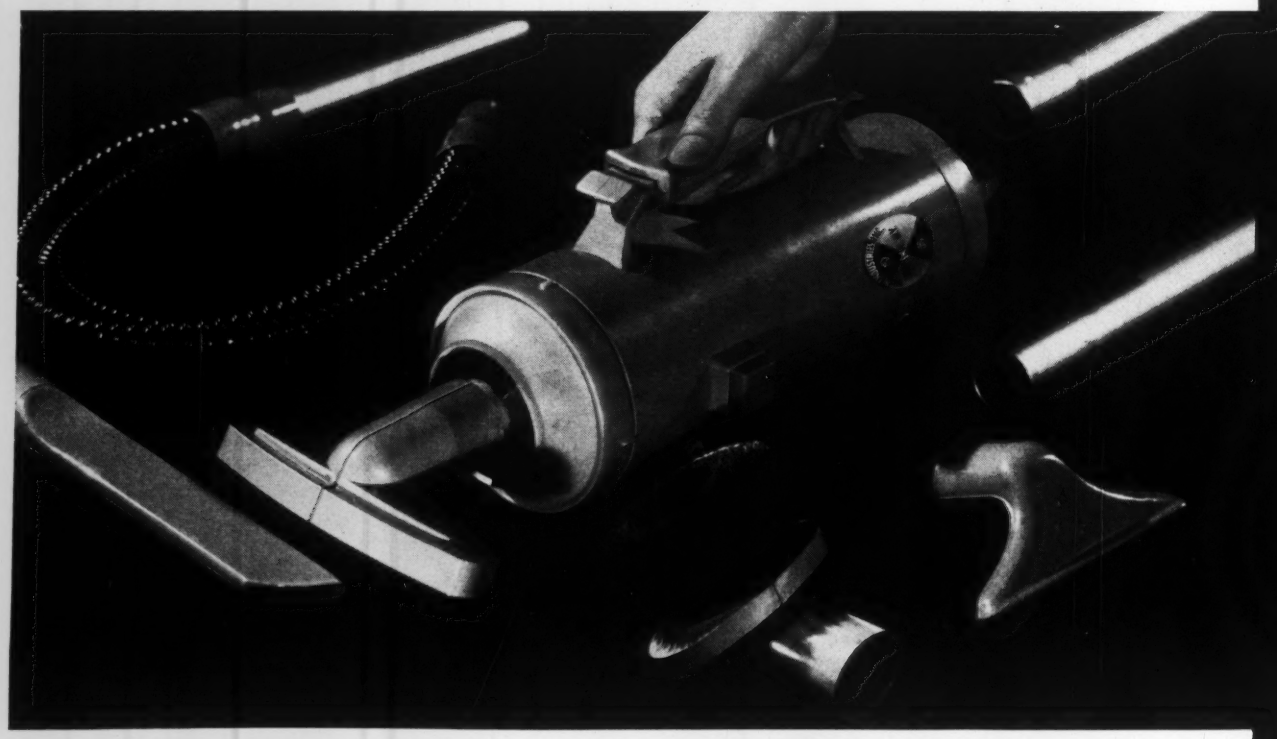
LIGHTWEIGHT STYRON MAKES VACUUM CLEANER SALES HUM

Dow thermoplastic replaces other materials, delivers production economy, attractive appearance.

The manufacturer of the compact vacuum cleaner shown below put plastics to full use in redesigning his product. The result is a lightweight, extremely portable and attractive unit that stimulates sales and gives the production man fewer headaches.

Styron® 475, one of Dow's high impact thermoplastics, was used for the housing and other rigid parts. The flexible parts are vinyl. The cleaner is available in two models, one for the home (pictured below) and one for industrial use. Lightweight Styron 475 makes the industrial version ideal for cleaning radio tubes, electronic equipment, electric motors and other products with hard-to-get-at corners and crevices.

In addition to a smartly styled appearance and a wide selection of colors, Styron 475 provides a warm touch pleasing to housewives. Compared to materials previously used, it trims costs by eliminating several fabrication and assembly operations. Like all Dow plastics, it gives the designer broad latitude and its quality is consistent and uniform. This contributes to greater production efficiency and fewer rejects.

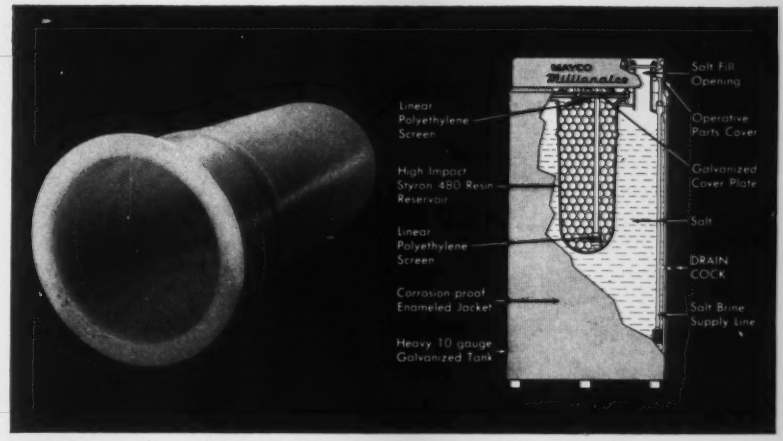


This compact, time and effort saving portable vacuum cleaner lightens the work of the housewife and the maintenance man. Its components are molded of tough, versatile Styron 475.

PLASTICS PERFORM

when pressure's on

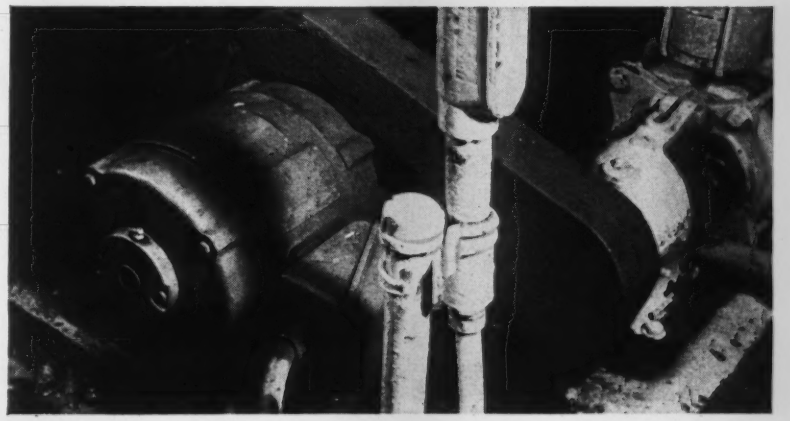
This water softener creates a vacuum in its recharging cycle, producing up to 120 lbs. pressure on every square inch on the surface of the tank. That's one of the many reasons Styron 480, Dow's *extra* high impact thermoplastic, with its great strength was chosen for the job. As Styron is rustproof, there are no corrosion problems. The excellent moldability of Styron helped in making this large, thick-walled reservoir. This application is typical of many developed for manufacturers by a plastics molder offering integrated design and production services.



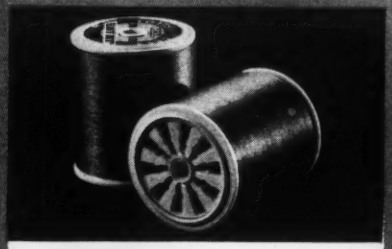
ACID VAPORS

can't hurt this motor!

This electric motor is located in a most unfavorable position—right in the middle of a chlorine plant. But the highly corrosive vapors and the ever-present moisture can't get at the vital parts because they're fully encased in a tough protective bed of epoxy resin. The motor has been in service more than two years without a single failure. Dow Epoxy Resins give greater over-all protection to all types of equipment because of high purity, rigid specifications and production dependability.

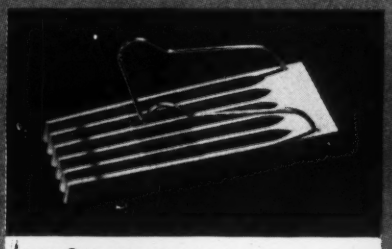


FOUR DISTINCTIVE PRODUCTS MADE OF DOW THERMOPLASTICS

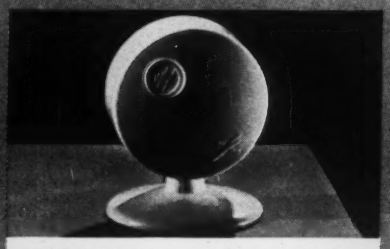


STYRON 475. Even the time-honored thread spool can be improved by plastics! No wood grain imperfections to worry about in smooth-surfaced, colorful Styron 475.

POLYETHYLENE. The extremely intricate mesh design of this Communion bag thoroughly demonstrates the excellent flow characteristics of Dow Polyethylene 990M.



TYRIL®. Tyril, a copolymer of styrene and acrylonitrile, provides rigidity, craze resistance and freedom from cracking in this unique pants hanger.



STYRON 475. Fine surface gloss, impact resistance, color selection and excellent electrical properties make Styron 475 ideal for this indoor TV antenna housing.

FOR MORE INFORMATION

. . . about the versatile Dow plastics and the products discussed on these two pages, write to us today. THE DOW CHEMICAL COMPANY, Midland, Mich., Plastics Sales Dept. 1701CD7.

THE DOW CHEMICAL COMPANY

Midland, Michigan

DOW

Industrial molding materials

●

Packaging materials

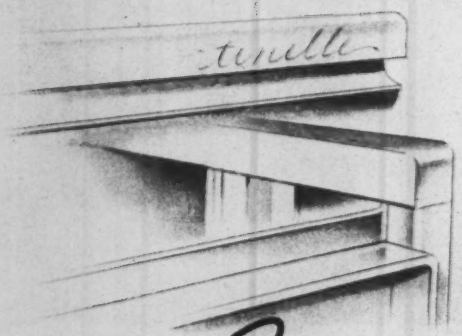
●

Paint and coating materials

●

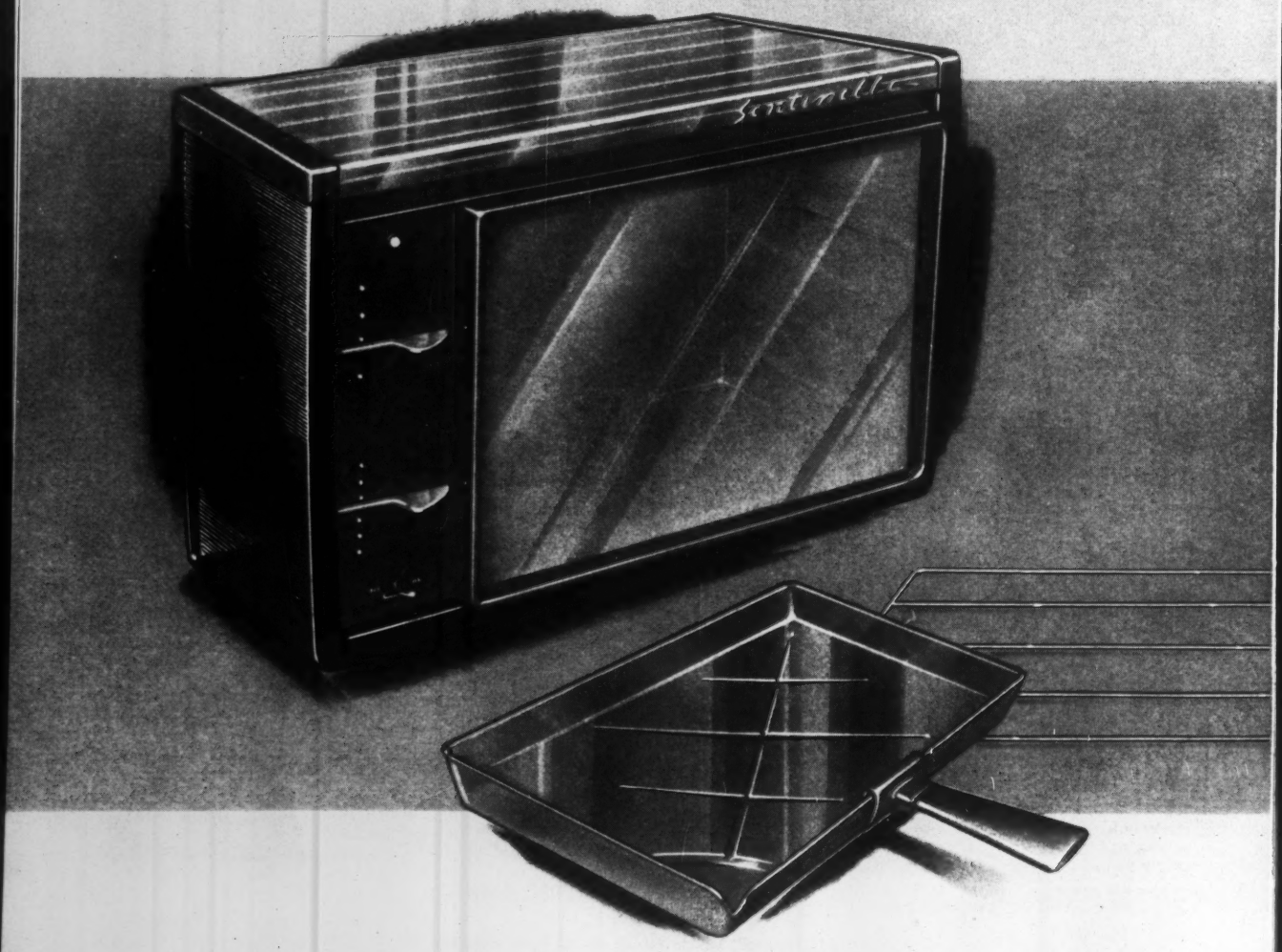
Building products

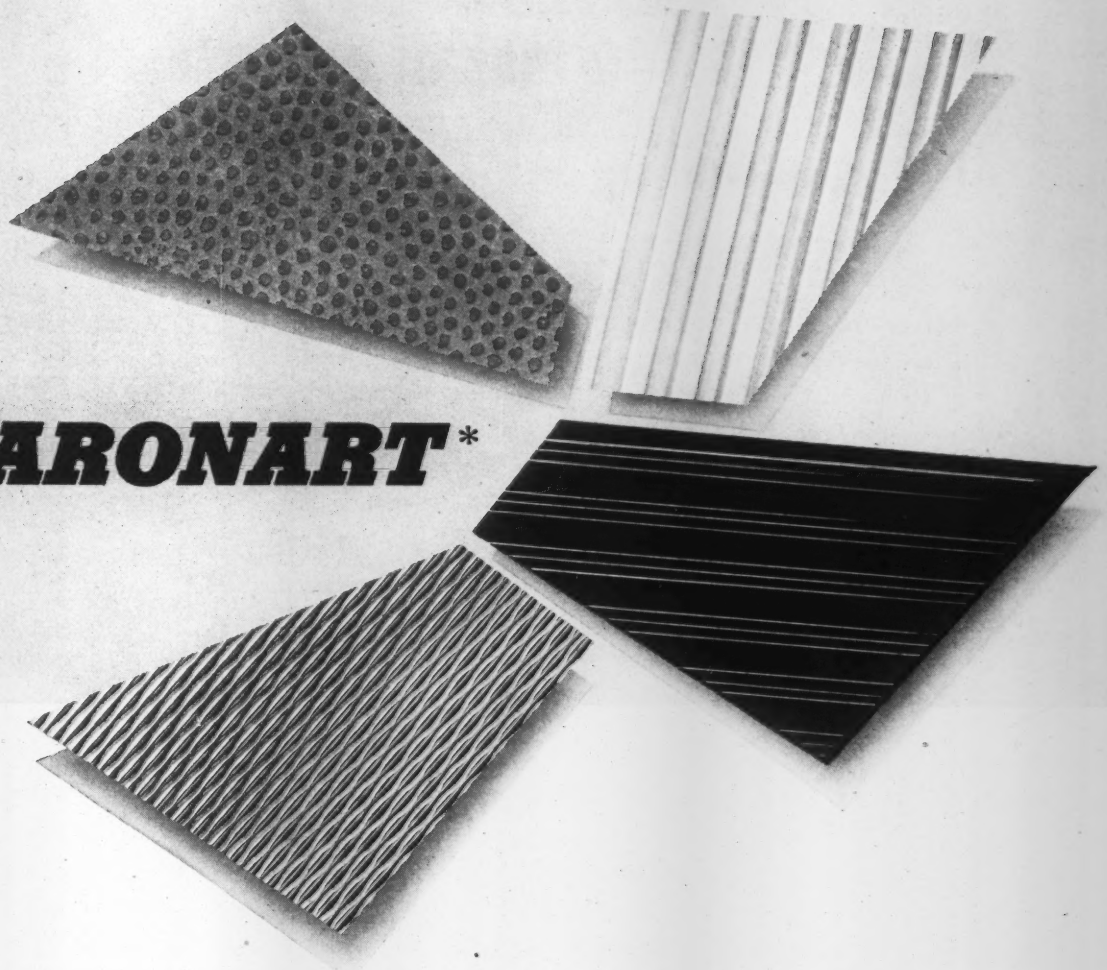
more information, turn to Reader Service card, circle No. 501



One of America's best known and most successful designers, Russel Wright, is practically a household word to Mrs. America. He, more than any other one man, has brought practical design to the average American housewife. Mr. Wright believes "good design" should be universal and his general aim is to create the widest variety of products for the widest possible market at the lowest possible cost so that "good design" can reach everyone.

Russel Wright **designs with..**





..SHARONART*

The portable broiler is high on the list of appliances most wanted by the modern American housewife. Until recently, little attention was paid to its design. The unwieldy bulk and lackluster styling of most models contrasted with the functional beauty of today's colorful kitchens and kitchen tools.

Russel Wright, world famed designer, has applied his talents to this appliance and has created a broiler with the attractive tailored look designed to harmonize with modern day kitchens.

In place of the outmoded polished chromium cover, Mr. Wright has utilized Sharon Steel's exciting new Sharonart* stainless in combination with a main shell of colored baked enamel over textured Sharonart*. Russel Wright has replaced impractical broiler operation with simple, functional, press-down levers that automatically set the thermostat and timer, and has included a stainless steel well-and-tree tray designed to be carried to the dining table and generous bakelite handles for safe carrying of the unit.

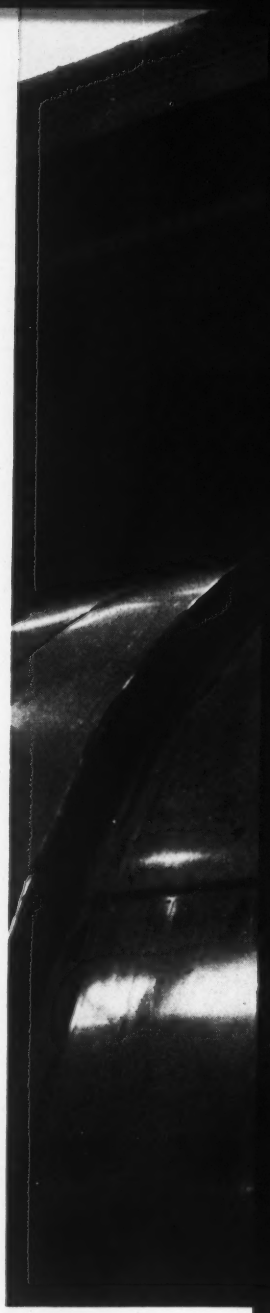
Whether you make broilers—or any other appliance—it's certain Sharonart* will give your product the same fresh look Russel Wright has achieved in this broiler design. *The Sharon Steel Corporation, Sharon, Pa.*

*T. M.

For more information, turn to Reader Service card, circle No. 450

SHARONSTEEL **SHARON** *Quality* **STEEL**

How to hang 40 tons of beer from the ceiling



These vessels, called "Dual-Paraboloid" fermentation tanks, are shaped like giant toasters. They're 21 feet long, 13 feet high, and 12½ feet at the widest point. Solar Chicago, Division of U.S. Industries, Inc., makes them from 13-gage Type 304 Stainless Steel sheets that are curved and welded together to form a cornerless interior. 1″ x 4″ ribs are welded around the outside of the tank and all welds are ground to a uniform finish.

Each of the tanks will hold 450 barrels, more than 40 tons, yet the tanks themselves are so light that the entire load will be hung from the ceilings of modern breweries. The formability, weldability and strength of Stainless Steel permitted this unique design. Because the Stainless is so strong, they could use thinner, *lighter* walls.

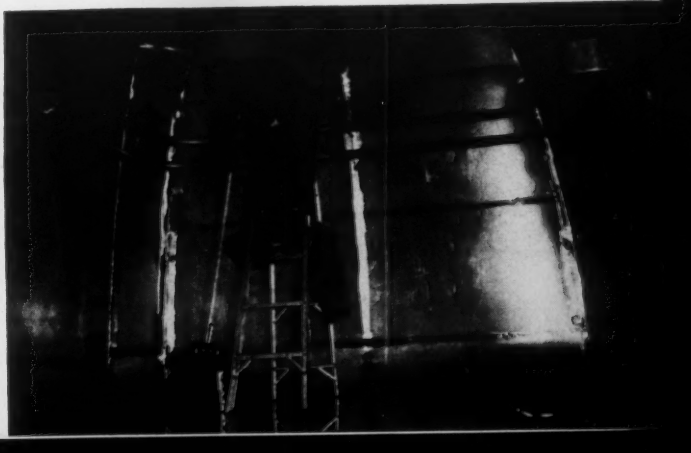
These tanks weigh 5 tons and they will replace old, square-cornered ones that weighed about *20* tons. Breweries are happy . . . the cornerless, Stainless tanks are easier to keep clean, and because they're off the floor, the plant itself stays cleaner. And because they're Stainless Steel, they will probably never have to be replaced.

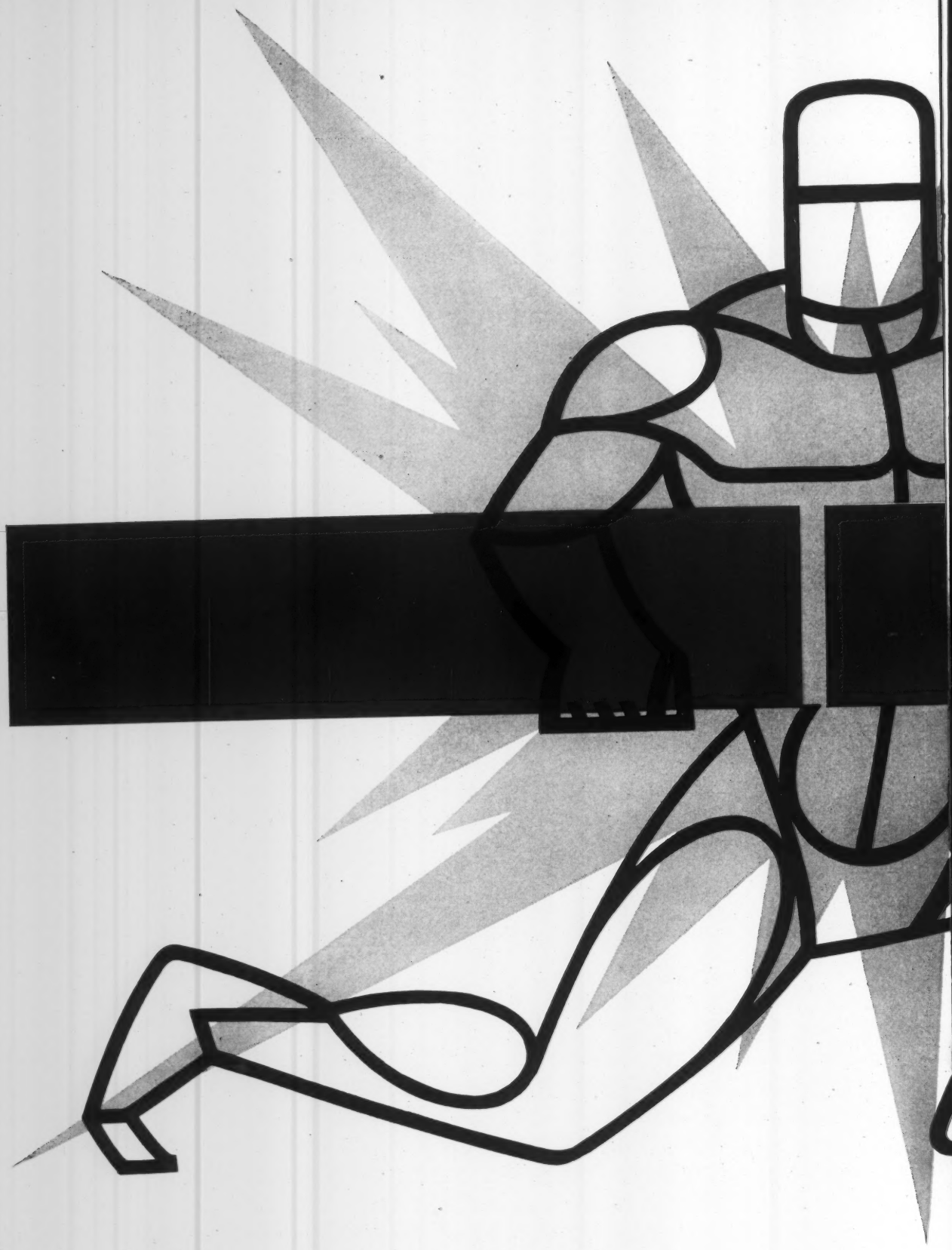
USS is a registered trademark

USS

United States Steel Corporation—Pittsburgh
American Steel & Wire—Cleveland
National Tube—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
United States Steel Export Company

United States Steel





COMBINES SUPERB WELDABILITY WITH EXTRA STRENGTH

N-A-XTRA

BEST LOW-ALLOY EXTRA-STRENGTH STEEL YOU CAN BUY

When only the strongest steels will do, specify N-A-XTRA HIGH-STRENGTH. This low-alloy heat-treated steel is now available in minimum yield strengths ranging from 80,000-110,000 psi.

Along with this great strength, N-A-XTRA is readily formed and fabricated. It can be welded by any process. The most drastic welding tests on N-A-XTRA have shown no underbead cracking, even when plate temperatures are as low as —60°F.

Because N-A-XTRA is nearly three times stronger than mild carbon steels, it gives designers an opportunity to eliminate useless dead weight from finished products and realize substantial savings. Let us show you how N-A-XTRA HIGH-STRENGTH steel can do a job for you. Write Great Lakes Steel Corporation, Detroit 29, Michigan, Dept. D-7.

GREAT LAKES STEEL

A DIVISION OF NATIONAL STEEL CORPORATION

For more information, turn to Reader Service card, circle No. 437

. . . economical alternative for solid and clad metals and alloys

Kanigen®

Stainless Steel Reactor Tube Bundle—
Inside of tubes, outside of tube sheet and hub Kanigen plated to reduce the danger of stress corrosion cracking.

KANIGEN, General American's unique process for chemical nickel alloy plating on most metals and alloys, offers an opportunity for large savings on chemical equipment.

KANIGEN makes possible the use of inexpensive basis metals for tankage, valves and piping, storage and reaction vessels. It is particularly satisfactory for austinitic stainless steels when stress corrosion cracking is a problem.

Complex shapes that vary in size from a 20,000 gallon tank car to a tiny control valve can be given a uniform coating of the required thickness with Kanigen. Coating may be done by rack, jig or barrel methods.

You can get **KANIGEN** chemical nickel alloy plating from General American at Sharon, Pa.; East Chicago, Ind.; or Compton, Cal., and from licensees in many cities. For detailed information or technical advice, call or write. You'll find... *IT PAYS TO PLAN WITH GENERAL AMERICAN.*

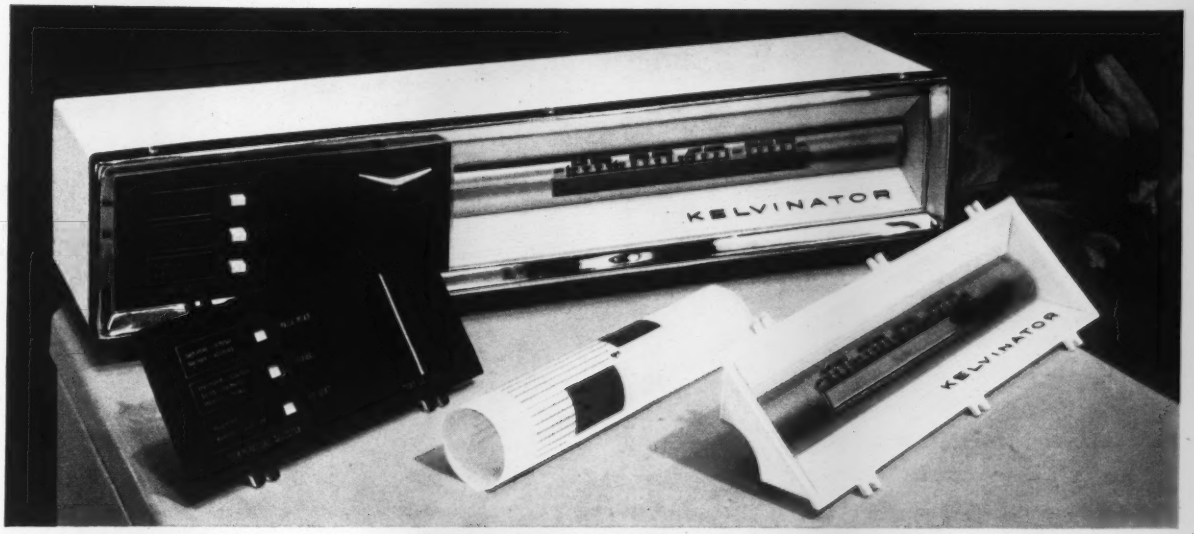
KANIGEN is a trademark which identifies chemical nickel coating by General American Transportation Corporation and its licensees, the product resulting therefrom and compositions produced by them for use in chemical nickel coating.

Write for Technical Bulletin #258

KANIGEN DIVISION
GENERAL AMERICAN TRANSPORTATION CORPORATION
135 South LaSalle Street • Chicago 90, Illinois

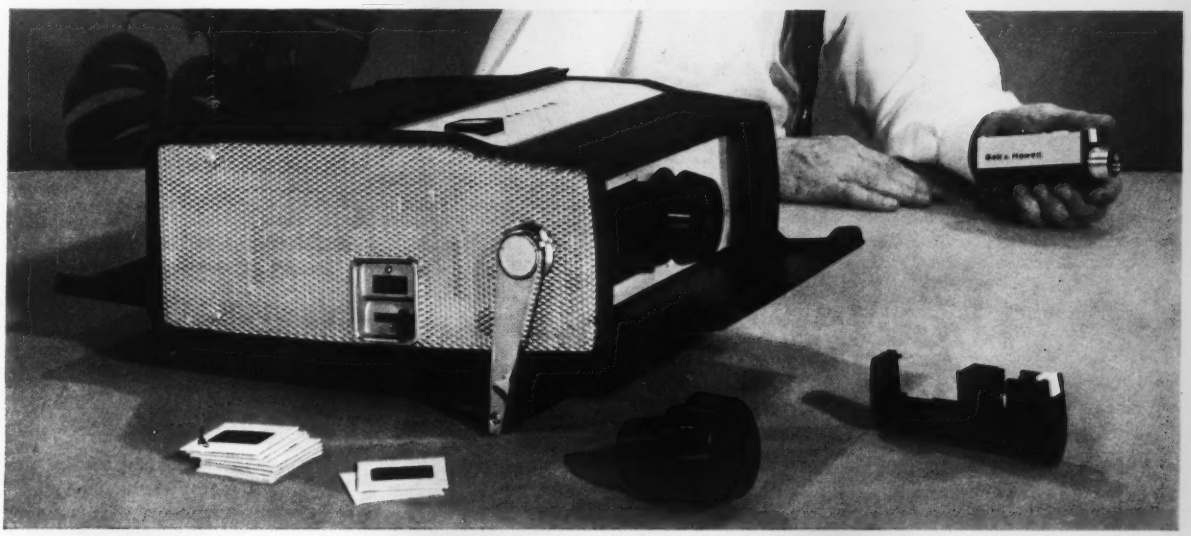
KANIGEN GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 442



Handsome and Hardworking

Plexiglas...Implex



for Kelvinator . . . PLEXIGLAS® acrylic plastic provides both beauty and strength for the handsome control panel on 1959 automatic clothes dryers. Pushbutton panel, backlighted Cycle-Vu window panel and rotary dial behind window are all made of PLEXIGLAS.

for Bell & Howell . . . Tough new IMPLEX® high-impact acrylic plastic gives outstanding strength and resistance to staining in components of "Explorer" slide projectors. Lens barrel container, and housing of Point-A-Ray remote control unit, are molded of IMPLEX.

for you . . . PLEXIGLAS and IMPLEX may be just what you need to give your products added sales appeal. Our design staff and technical representatives will be glad to tell you about these Rohm & Haas molding materials.

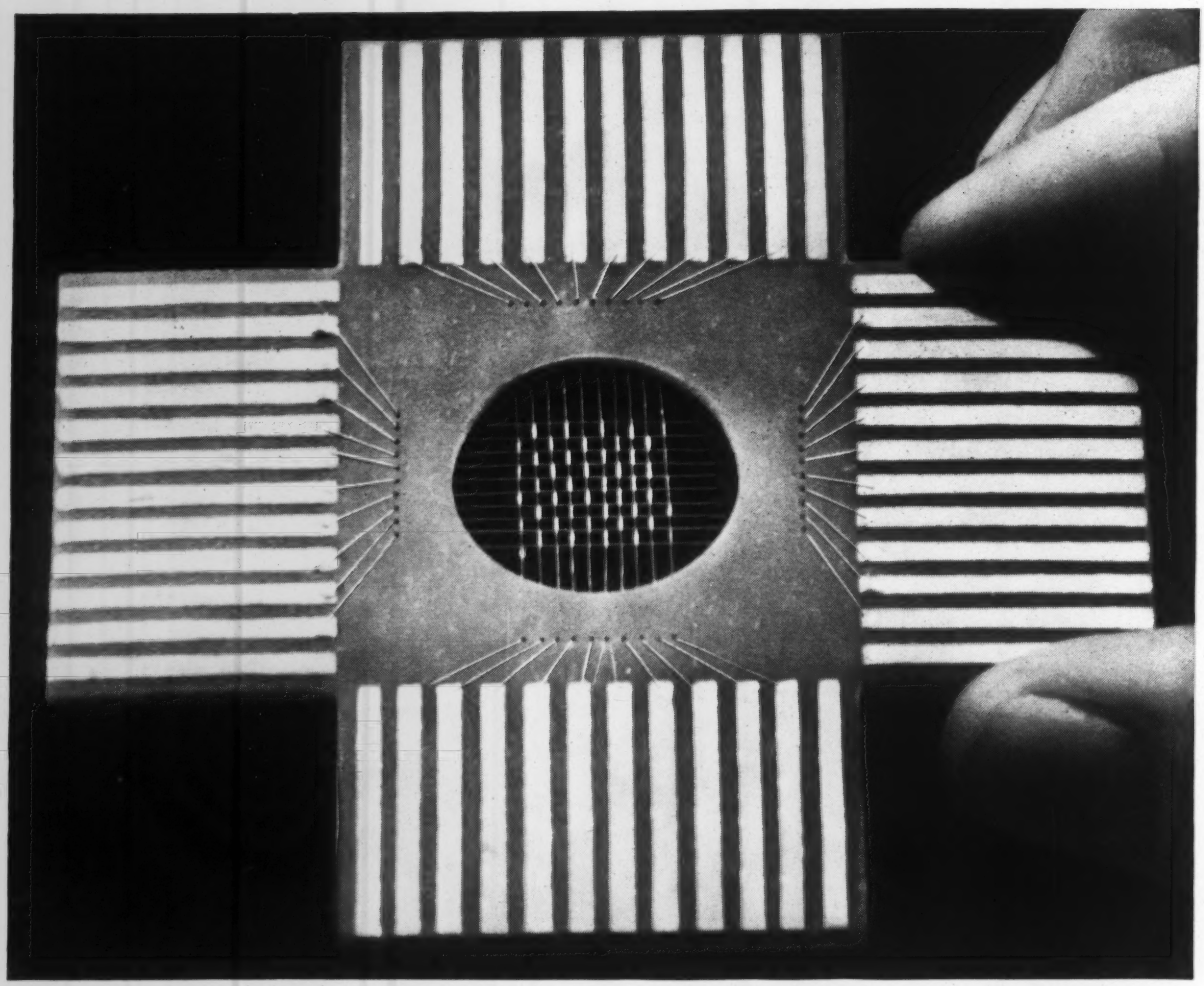
Chemicals for Industry

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

In Canada: *Rohm & Haas Co. of Canada, Ltd., West Hill, Ontario*

For more information, turn to Reader Service card, circle No. 363



New twist in memory devices. This simplified model illustrates the basic structure of the "Twistor" magnetic memory. Developed by Bell Telephone Laboratories, the Twistor depends on unique magnetic properties of high-nickel alloy wire.

They twist high-nickel wire to make a machine remember

A new child's toy? Hardly.

This tiny part is an ingenious new kind of magnetic memory. It may well be the heart of the computer of the future.

They call it the "Twistor." It takes advantage of the unusual magnetic behavior of a twisted high-nickel alloy wire.

A group of these wires, interwoven with other wires to form a screen-like grid, can store thousands of "bits" of information magnetically, ready to answer the call of the computer.

The result is a magnetic memory device that costs and weighs less, yet is more compact and rugged than conventional devices.

What makes the Twistor practical is a unique magnetic property found in the high-nickel alloy used for the wire: when twisted, its preferred direction of magnetization shifts from a longitudinal to a helical path. In addition, this alloy permits operation with very low currents so its minute energy requirements are easily supplied by transistor circuits. And, of course, since the alloy is mainly Nickel, corrosion is no problem.

For new twists in design – or in solving metal problems, – Nickel or one of its alloys may offer what you are looking for. If corrosion, wear, high or low temperatures, stresses or fatigue are factors, let's get together to talk it over.

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

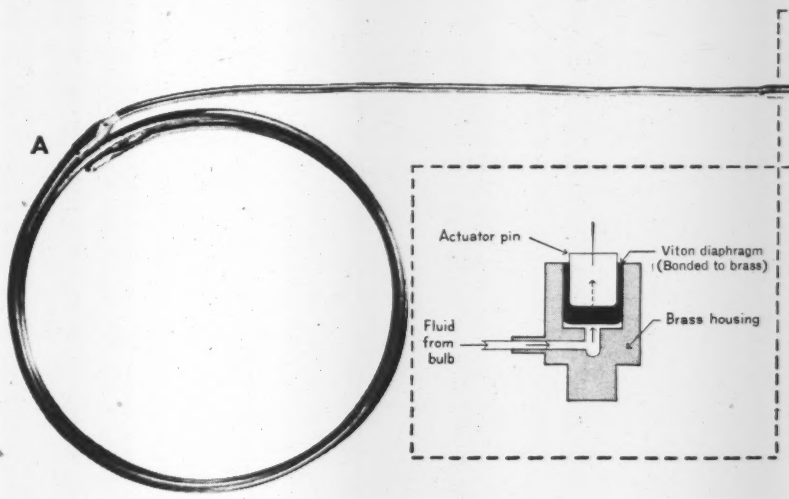
INCO

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

For more information, turn to Reader Service card, circle No. 362

This improved thermostat couldn't work without **VITON®**



Actual size of thermostat

HOW IT WORKS—Heat-expansible fluid inside the bulb (**A**) expands through copper tube to thermostat (**B**). Fluid exerts pressure against VITON diaphragm inside thermostat. Diaphragm pushes against a metal actuator pin which trips electrical contact or control valve. VITON synthetic rubber provided the necessary fluid and heat resistance that made this design practical.

Instrument designers have long recognized the advantages of using a thermostat with an elastomeric diaphragm for electric and gas ranges as well as other appliances. Such a thermostat could be made smaller than bimetallic or metal diaphragm types, would be much more sensitive to temperature changes, operate more quickly—and cost less.

But, until recently, no elastomer was available that would hold up in service. Those tested swelled in contact with the heat-expansible fluid used in the thermostat or they were unable to stand the high operating temperatures. Either the heat or fluid always destroyed the thermostat's accuracy . . . if not the synthetic rubber diaphragm itself.

New DuPont VITON synthetic rubber has solved both these problems. VITON easily withstands the required temperatures (from 300° F. to 400° F.). It has good adhesion to brass—essential to the proper functioning of the diaphragm. The bulb fluid does not attack the VITON—even at 400° F. temperatures—nor does it permeate the rubber diaphragm.

As a result, a completely practical elastomeric thermostat is now available. Its bulb volume is roughly 1/8 that of diaphragm-type thermostats previously used. It operates quicker and with greater sensitivity to temperature changes than other types . . . and can be fabricated at much lower total materials cost.

Wherever *you* need an elastic material that can stand high temperatures (450° F. and up), oils, solvents, chemicals . . . and offer outstanding mechanical properties as well . . . consider VITON. For more information about this new synthetic rubber, write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MM-7, Wilmington 98, Delaware.

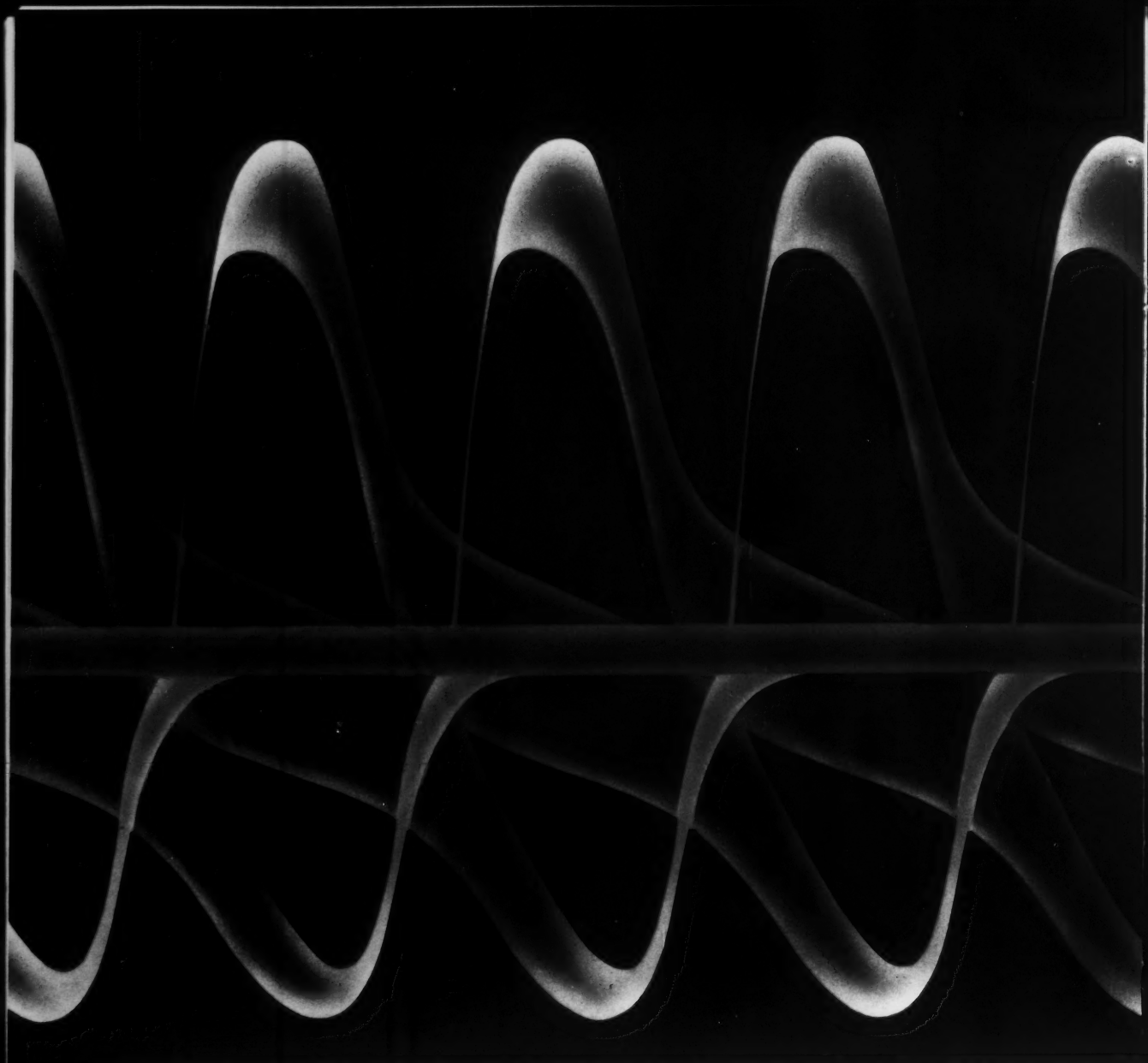
DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON®
ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

For more information, turn to Reader Service card, circle No. 445



The cathode ray oscilloscope is one of science's and industry's most perceptive instruments for determining uniformity of operation. The pattern reproduced here is a harmonically modulated sine wave of exact uniformity.

Uniformity is Malleable

Just as the input of an oscilloscope can be controlled to produce repetitive patterns, so can consistently uniform metal parts be produced with Malleable iron because of modern, scientific controls. The unique method by which all Malleable castings are made and the exacting techniques employed by Malleable foundries assure Malleable users of castings that are uniform, part after part, regardless of size or shape. This uniformity, combined with unparalleled physical and mechanical properties, ideally suits Malleable castings for modern America's quality products.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER

MALLEABLE

CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

(Advertisement)

Better Products at Lower Cost Result From Malleable Uniformity Controls

Uniform quality — whether for five or five million pieces — is essential to maintain product quality and increase manufacturing efficiency. With accelerating frequency, Malleable castings contribute their unique uniformity in critical applications where durable, reliable components are necessary.

Key to Uniformity is Control

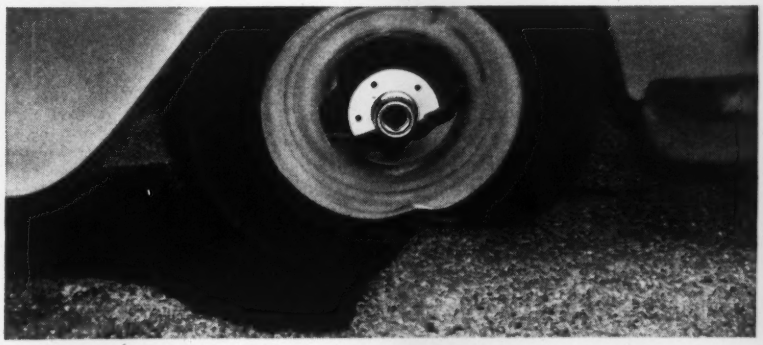
Malleable iron is produced under closely controlled manufacturing techniques. From charge composition and molding sand properties, through final inspection, every critical factor is held constant by using the most modern techniques of metal analysis, process control and inspection.

Internal Uniformity

This versatile engineering material is achieved through converting the base white iron into tough Malleable iron by a controlled heat treating process. Malleable's internal structure exhibits excellent uniformity, an important factor in assuring the dependable performance of intricately designed components.

External Uniformity

Fundamental to the casting process is the ability to produce a given shape, time after time, in either small or large quantities. Metal can be placed exactly where it is needed . . . eliminated where it is not. Good design — achieved through close cooperation between the customer and the foundry — can assure the necessary tolerances and the lowest possible finished part cost. Modern techniques of production and inspection are used to insure top quality, dimensionally accurate castings.



The life of every motorist rides in complete safety on Malleable wheel hubs of unerring uniformity.

Uniformity Proven by Use

The final test of any part is how well it stands up in actual service. Under continuous cyclic and shock loading, the millions of Malleable wheel hubs, which are in service on the front end of every American-made car, have compiled an enviable record of proven uniformity. Another dramatic example of Malleable's uniformity is proved in the old adage "A chain is only as strong as its weakest link." Miles of Malleable chain, carrying tremendous loads year after year without failure, demonstrate the uniformity of every cast link.

New techniques for controlling every element of Malleable production are the result of intensive research done by Malleable foundries in their continuing search for ways to make Malleable even more versatile and indispensable to industry.

More Information Available

Your copy of *Data Unit 103—Uniformity* — is available from any member of the Malleable Castings Council. If you prefer, write direct to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

MALLEABLE CASTINGS COUNCIL

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Link-Belt Company, Indianapolis 6
Muncie Malleable Foundry Co., Muncie
Terre Haute Mall. & Mfg. Corp., Terre Haute

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

For more information, turn to Reader Service Card, circle No. 393

COPPER MAKES BEAUTIFUL MUSIC

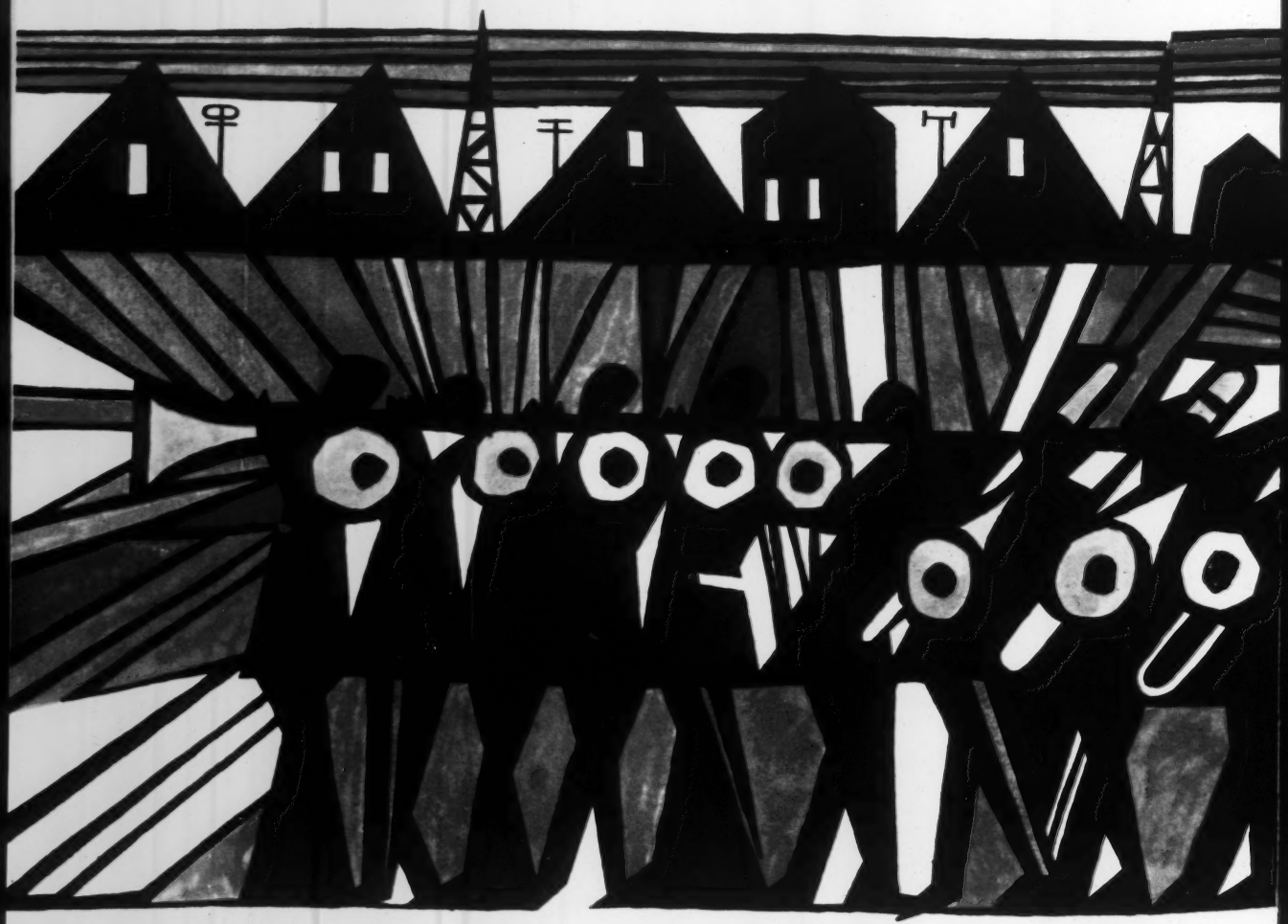
round tones, deep tones, sharp tones, flat tones.
copper makes brass, bells and bugles, trumpets and trombones.

copper makes bronze for a beethoven bust.

and copper makes wire. wire, wire, printed wire.
wire for radio, wire for stereo. wire for telephony and tv.

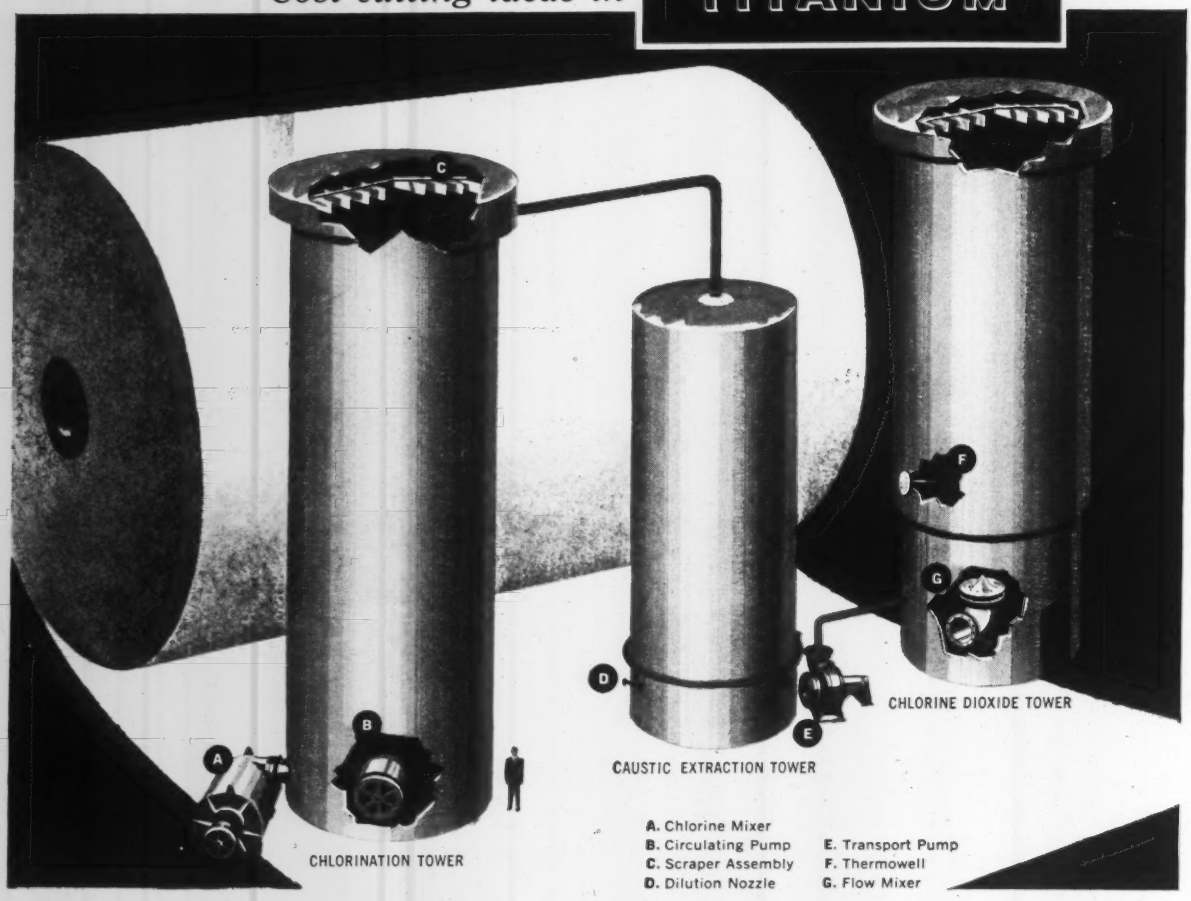
music. modern music. copper's the conductor.

without copper . . . how still the air.

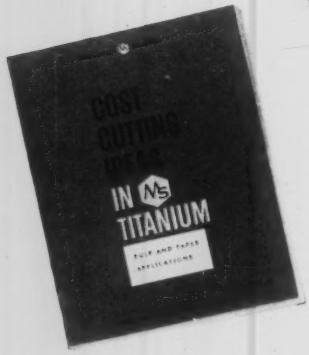


♀ For information about Copper and Copper Alloys, write Copper & Brass Research Association, 420 Lexington Avenue, New York 17, N. Y.

Cost cutting ideas in **TITANIUM**



TITANIUM BELONGS IN THIS CORROSIVE PROCESSING PICTURE



Write for *Technical Data Sheets on "Cost Cutting Ideas in Titanium for the Pulp and Paper Industry"— on your business letterhead, please. Address: Commercial Market Development, Dept. C, Mallory-Sharon Metals Corporation, Niles, Ohio.*

Here's why: Today, titanium is competitive pricewise with nickel base alloys when density is taken into account. Its service life is often many times that of nickel base alloys or stainless steel. And titanium is about the same to weld and fabricate.

The corrosion resistance of titanium in chlorine dioxide and hypochlorite solutions is outstanding. No wonder it is rapidly finding new applications in the pulp and paper and chemical industries.

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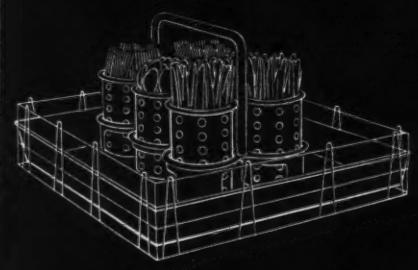

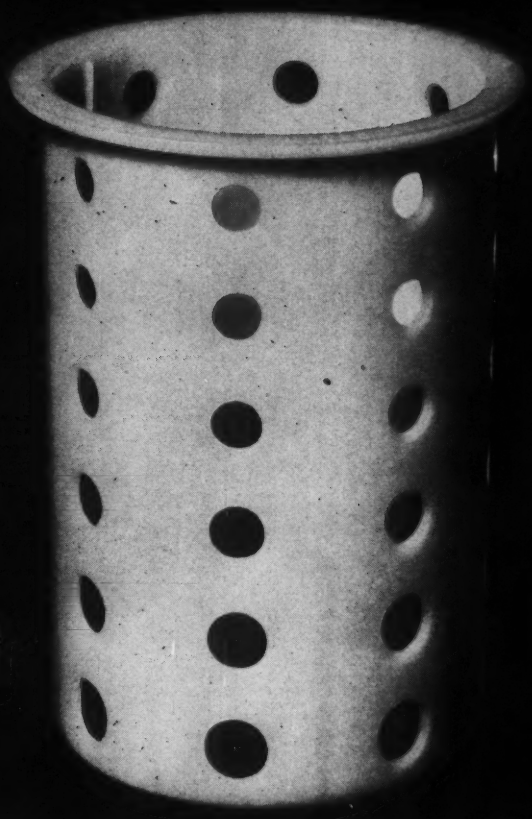

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TYPICAL PHYSICAL AND CHEMICAL PROPERTIES OF FORTIFLEX

Properties of Fortiflex "A" Related to Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	FORTIFLEX RESINS A-20	A-70	A-250	A-500
Melt Index	D-1238-52T	—	0.2	0.7	2.5	5.0
Heat Distortion Temp. (66 psi)	D-648-45T	°F.	185	185	180	180
Brittleness Temp.	D-764-52T	°F.	−200	−180	−160	−100
Impact Strength, izod (⅛" x ½" injection-molded bars)	D-256-54T	ft. lb./in. notch	23	18	13	3
Tensile Strength, Max., 0.2 in./min.	D-638-52T	psi.	3700	3600	3500	3300
Elongation, First Tensile Yield Point	D-638-52T	%	25	25	25	25

Properties of Fortiflex "A" Not Affected by Melt Index

PHYSICAL PROPERTIES	ASTM METHOD	UNITS	VALUE
Density		g/cc.	0.96
Refractive Index	D-542-50	n_D^{25}	1.54
Hardness, Shore D	D-676-49T		65
Stiffness	D-747-50	psi.	150,000
Water Absorption (⅛" specimen, 24 hr. immersion @ room temp.)	D-570-54T	%, wgt. gain	<0.01
Flammability	D-635-44	in./min.	1.0
*Mold Shrinkage, length		in./in.	0.03 to 0.05
width		in./in.	0.02 to 0.04

*Measured on injection molded tensile bar. Mold shrinkage depends on part design and molding conditions.

Celanese Corporation of America, Plastics Division,
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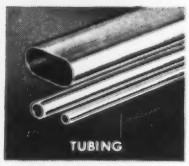

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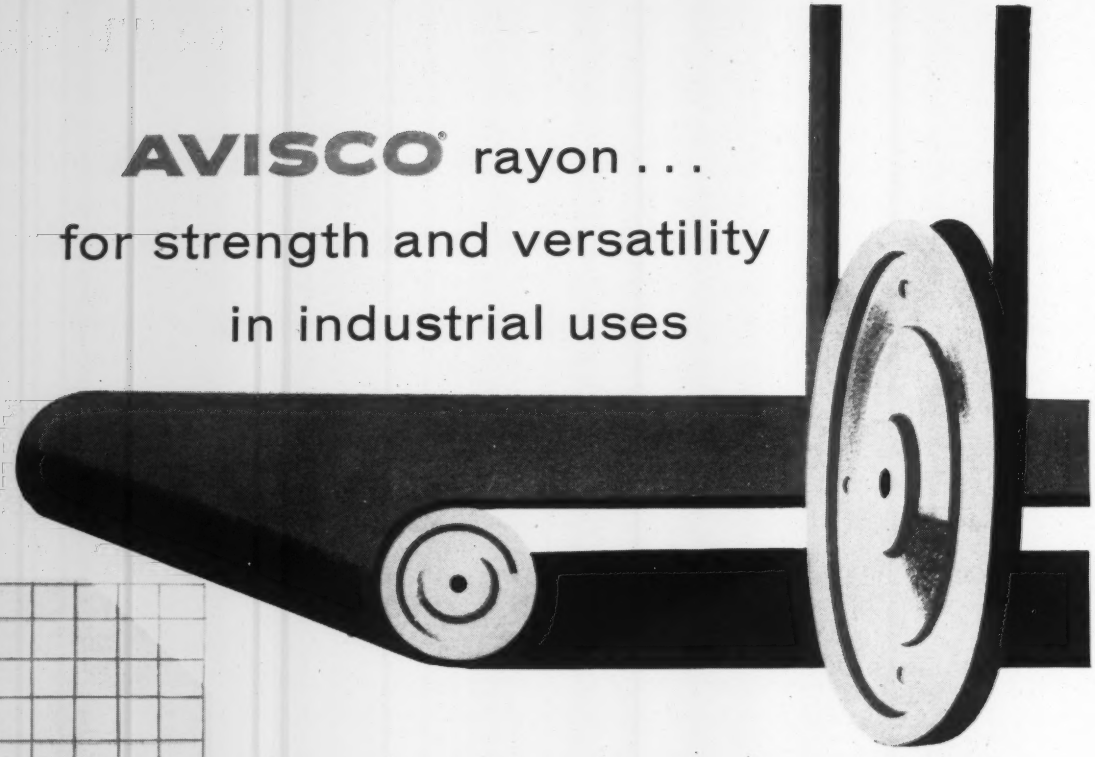

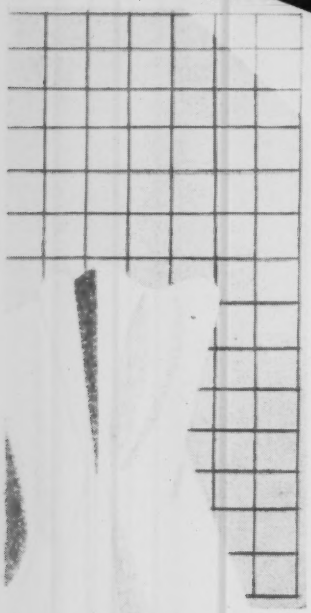

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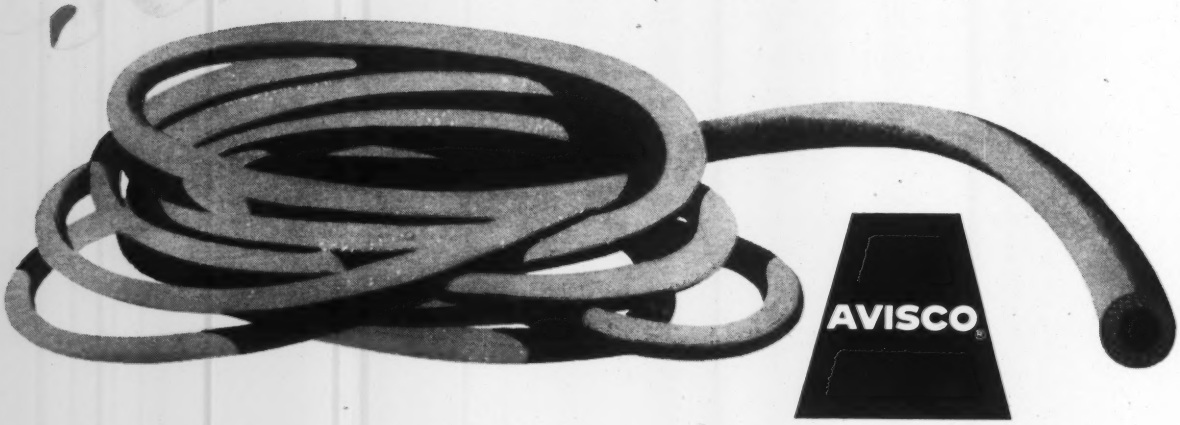

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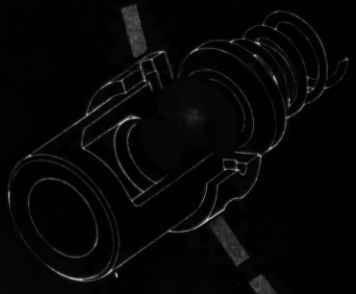

Pilot section of this pressure relief valve has poppet ball (red) and seat of LINDE Sapphire. Valve was designed and manufactured by Whittaker Controls Division of Telecomputing Corporation.

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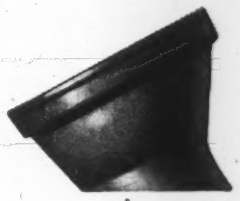

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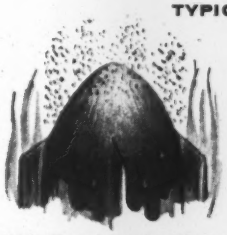
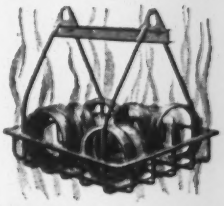
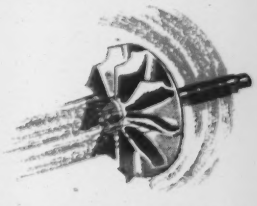


ABRASION. Ten times the life and still no sign of wear, is the record of this plastics-extrusion torpedo nose made of HAYNES STELLITE alloy No. 3. This is one of many HAYNES wear-resistant alloys.



CORROSION. Baskets made of HASTELLOY alloy C used for holding forgings during acid treatment, are still good after 15 months of service. Materials formerly used were replaced every month.



HIGH TEMPERATURE. Turbine wheels in the "hot" ends of diesel engine turbochargers are investment-cast of HAYNES STELLITE alloy No. 31, for service at speeds up to 50,000 rpm. at 1500 deg. F.

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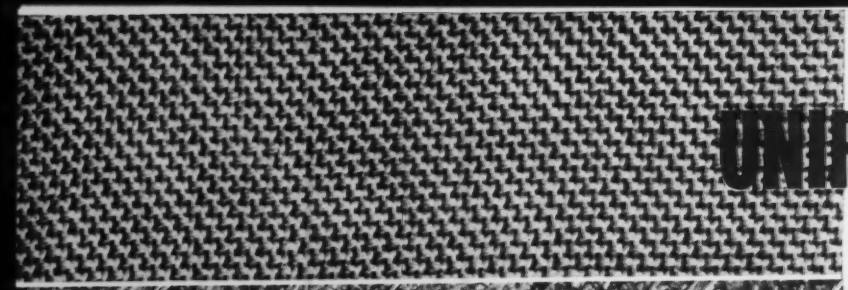

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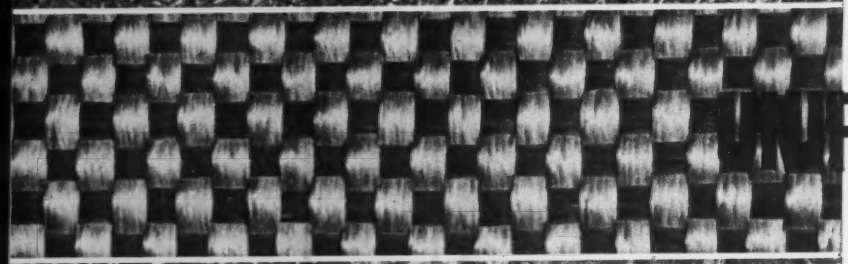

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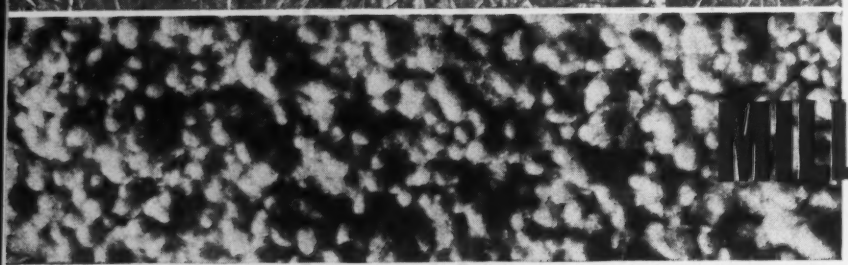

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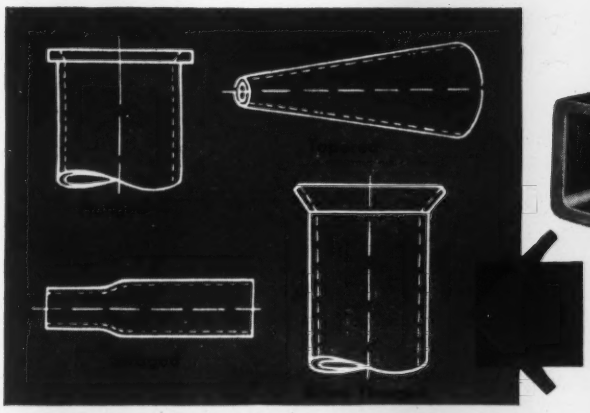
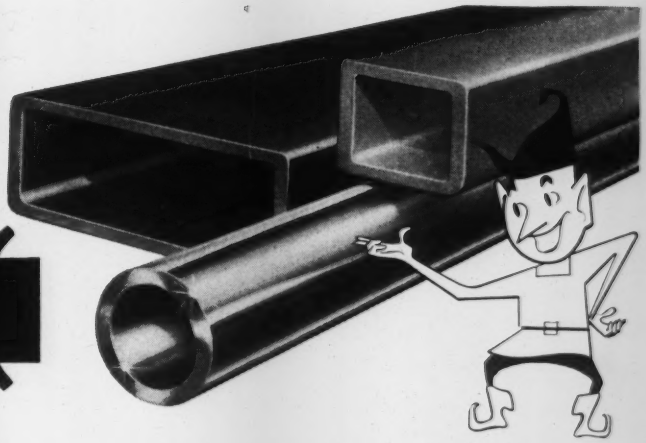
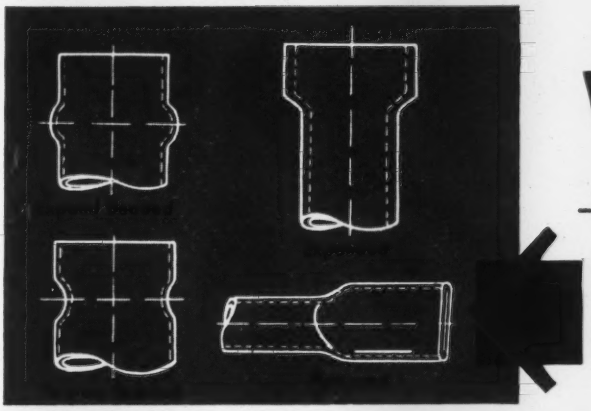
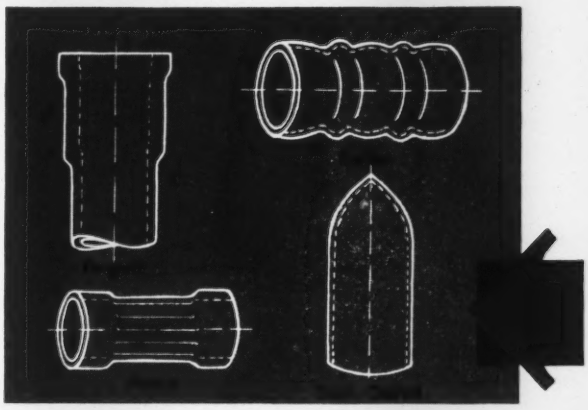
Fiberglass Ave., Nashville 11, Tenn. • Huntington Beach, Calif.

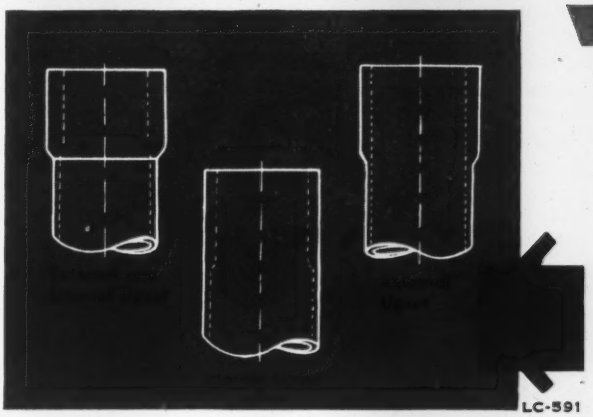
For more information, turn to Reader Service card, circle No. 436











LC-591

WELDED TUBING

fabricates

every way

Welded steel tubing fabricates readily by all methods because of its inherent properties and uniformity of dimension and wall thickness.

Shown at left are some basic tube fabricating possibilities, and welded steel tubing fits them all. It is readily machinable, joins by literally every known method, and is available in all weldable grades of carbon, stainless steel and other alloys in round and special shapes.

When it's tubing you need—specify *welded* steel tubing from one of the quality tube producers.

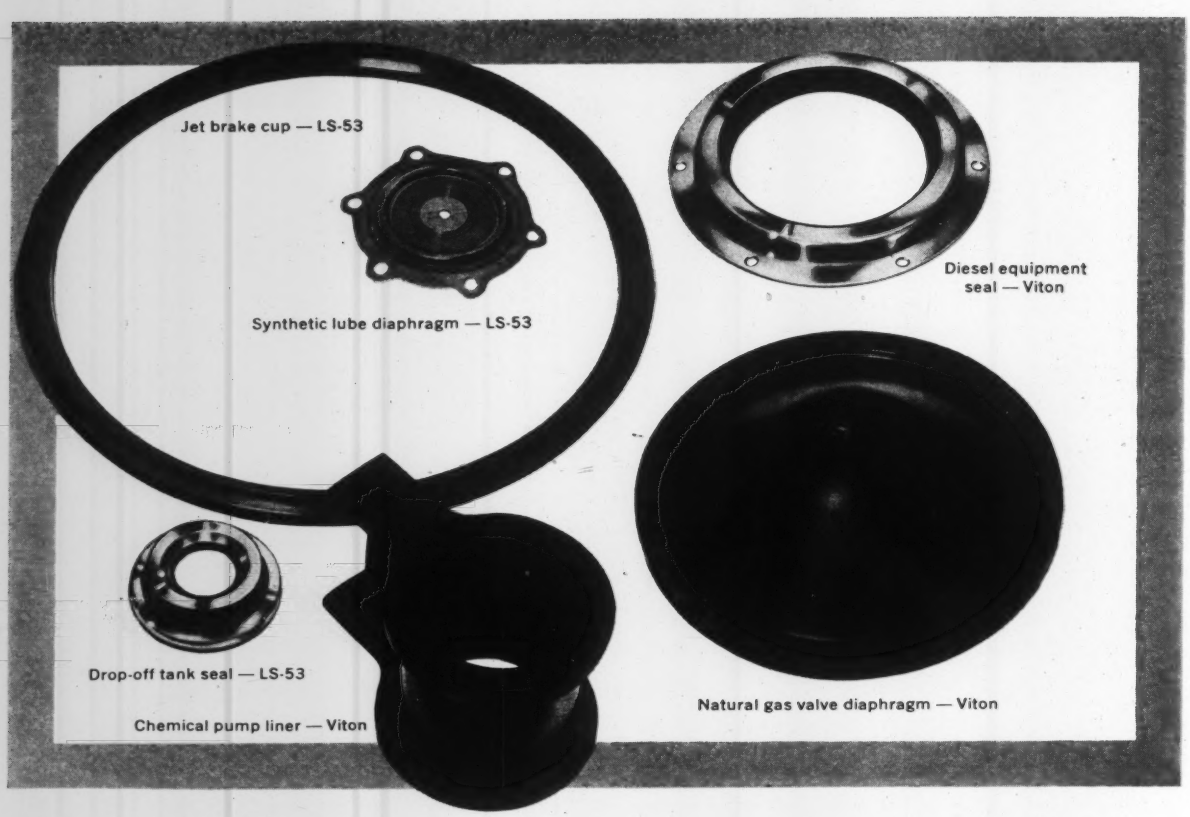
WRITE for Bulletin 8591 "Welded Steel Tubing."

FORMED STEEL TUBE INSTITUTE, INC.

850 HANNA BUILDING
CLEVELAND 15, OHIO

• Armco Steel Corp. • The Babcock & Wilcox Co., Tubular Products Div. • The Carpenter Steel Co., Alloy Tube Div. • Clayton Mark & Co. • Damascus Tube Co. • Jones & Laughlin Steel Corp., Electricweld Tube Div. • National Tube Div., United States Steel Corp. • Ohio Seamless Tube Div. of Copperweld Steel Co. • Republic Steel Corp., Steel and Tubes Div. • Revere Copper and Brass Inc., Rome Manufacturing Company Div. • Sawhill Tubular Products, Inc. • Southeastern Metals Co. • The Standard Tube Co. • Standard Tube and T. I. Ltd., (Canada) • Superior Tube Co. • Trent Tube Co., Subs. Crucible Steel Co. of America • Wall Tube & Metal Products Co.

For more information, turn to Reader Service card, circle No. 388


Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears

C/R

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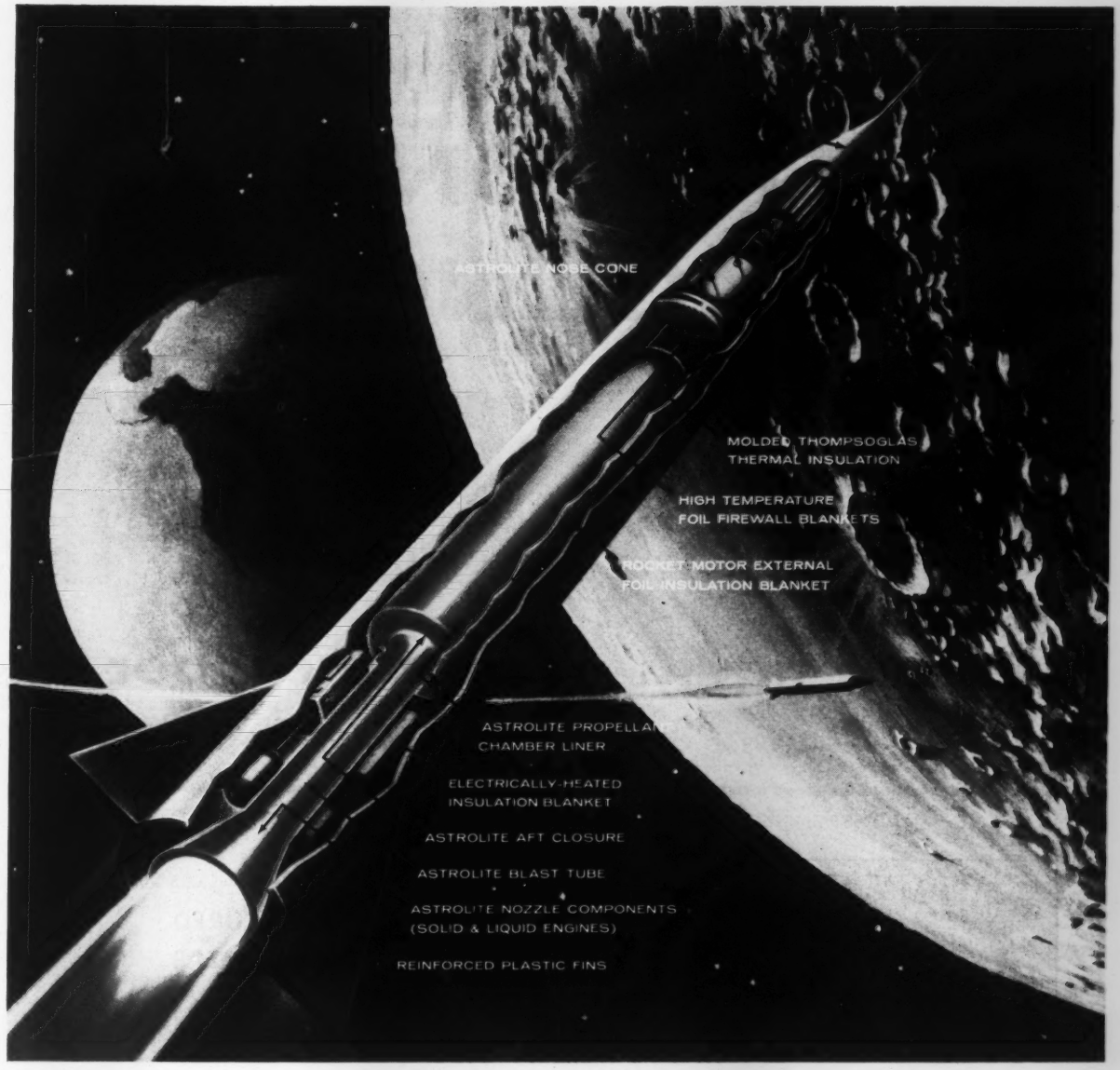

ASTROLITE NOSE CONE
MOLDED THOMPSOGLAS THERMAL INSULATION
HIGH TEMPERATURE FOIL FIREWALL BLANKETS
ROCKET MOTOR EXTERNAL FOIL INSULATION BLANKET
ASTROLITE PROPELLANT CHAMBER LINER
ELECTRICALLY-HEATED INSULATION BLANKET
ASTROLITE AFT CLOSURE
ASTROLITE BLAST TUBE
ASTROLITE NOZZLE COMPONENTS (SOLID & LIQUID ENGINES)
REINFORCED PLASTIC FINS

MISSILE DESIGN WITH HITCO IN MIND

Missile design is probably the world's most exacting technology relative to the need for high temperature insulation materials.

HITCO is one of the world's leading developers and manufacturers of ultra-performance thermal materials capable of resisting extremely high temperatures, even up to 15,000°F. for short duration!

If you are looking for down-to-earth answers for out-of-this-world high temperature problems, keep HITCO in mind in your Missile Design!

- REFRASIL Materials
- HITCO Metal Blankets
- THERMO-COUSTI Materials
- THOMPSOglas Materials
- ASTROLITE Reinforced Plastics
- HITCORE Structural Core Materials

Call or write us for Capabilities Brochure and complete Technical Data on HITCO Products.

H. I. THOMPSON FIBER GLASS CO. HITCO *1733 Cordova Street • Los Angeles 7, Calif. • REpublic 3-9161*

WRITE OR CALL YOUR NEAREST HITCO REPRESENTATIVE: EASTERN: Tom Kimberly, 38 Crescent Circle, Cheshire, Conn., BR. 2-6544; Fred W. Muhlenfeld, 6659 Loch Hill Rd., Baltimore 12, Md., VA. 5-3135 • **MIDWEST:** Burnie Weddle, 3219 W. 29th St., Indianapolis 22, Ind., WA. 5-8685 • **SOUTHWEST:** Marshall Morris, 2850A W. Berry, Rm. 7, Fort Worth, Tex., WA. 4-8679 **NORTHWEST:** J. L. Larsen, 5757 Oaklawn Pl., Seattle, Wash., PA. 5-9311 • **CANADIAN PLANT:** THE H. I. THOMPSON CO. OF CANADA LTD., 60 Johnston St., Guelph, Ont., TA. 2-6630

For more information, turn to Reader Service card, circle No. 434

DU PONT ANNOUNCES

ADIPRENE® L

a new liquid urethane rubber

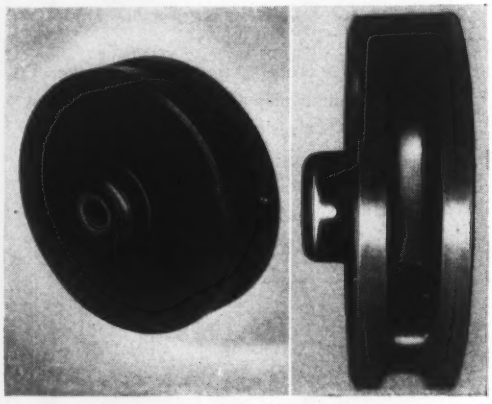
Hardness, Shore A	88	95	97	99+
Hardness, Shore D	43	48	60	78
Modulus, 300%, psi	2100	3200	7000	—
Tensile Strength at Break, psi	7000†	8825†	8500†	8500†
Elongation at Break, %	450	480	340	250
Split Tear, ASTM-D 470 lbs./linear inch	50	155	160	200
Compression/Deflection, psi @ 5% defl.	275	375	650	1400
Rebound Resilience, %	45	40	42	45
Oil Resistance	Excellent	Excellent	Excellent	Excellent
Low Temperature Brittle Point, °F.	<-80	<-80	<-80	<-80

PROPERTIES OF CURED ADIPRENE L POLYMERS

(High Hardness Compounds*)

*Softer compounds ranging from 10 Shore A are also available.

†Samples pulled @ 1"/minute (elastomer stocks normally pulled at 40"/min.)



ABRASION — ADIPRENE pump impellers, like this one, have handled 380,000 tons of solids in the form of an abrasive acid slurry without need for replacement. Normal life expectancy for impellers made of other materials is 170,000 tons of solids.

ADIPRENE L is an improved urethane rubber researched and developed by the Elastomer Chemicals Department of Du Pont. It offers the designer a new material that combines the resilience of rubber with the hardness and load-carrying capacity once found only in metals and hard plastics.

In its raw state, ADIPRENE L is liquid in form. Cured polymers can be made in varying hardnesses—from 10 to 99 Shore A (78 Shore D). These vulcanizates are outstanding in abrasion resistance, low temperature performance, and oil resistance. They resist the attack of oxygen, ozone, radiation, many chemicals and solvents.

You will want to evaluate this new synthetic rubber in improving the products you design. The performance data presented below will suggest areas where ADIPRENE L might be useful to you. More complete information is contained in our new booklet. Send the coupon today for your copy. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MMA-7, Wilmington 98, Del.

SEND FOR MORE INFORMATION

E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MMA-7
Wilmington 98, Delaware

☐ Please send me your new booklet on ADIPRENE L, outlining the properties and design possibilities of this new Du Pont elastomer.

☐ I am particularly interested in the application of ADIPRENE L to the following product:

_____

Name _____

Firm _____

Title _____

Address _____

City _____ *Zone* ____ *State* _____

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON®
ADIPRENE®

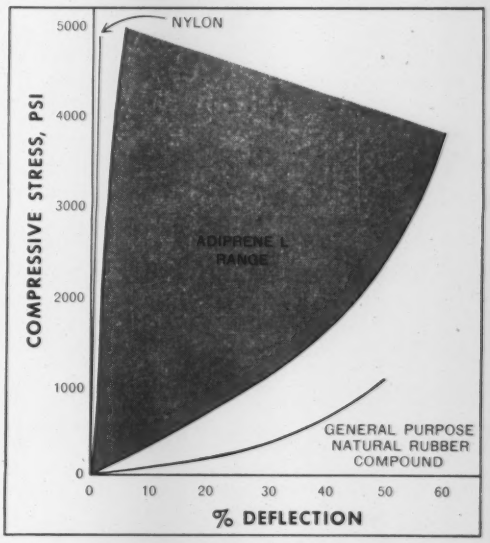
Better Things for Better Living . . . *through Chemistry*

AN OUTSTANDING COMBINATION OF HARDNESS, RESILIENCE AND LOAD BEARING CAPACITY—ADIPRENE L polymers combine high hardness with elasticity. As a result, you might use them to replace metal or similar non-elastomeric materials in applications where cushioning or damping properties would improve performance or wear. Industrial rolls, ball joint liners, motor mounts, sleeves and bushings, striker plates, and sealing devices are just a few of the possibilities.

OUTSTANDING AT SUB-ZERO TEMPERATURES—ADIPRENE L vulcanizates do not become brittle at temperatures as low as –80° F. and exhibit outstanding resistance to thermal shock.

OUTSTANDING ABRASION RESISTANCE—Both in the laboratory and in actual service, ADIPRENE L has demonstrated its ability to resist wear. On caster wheels for fork lift trucks, as an example, tires made of ADIPRENE give 8 to 10 times the performance of conventional rubber and plastic tires.

OTHER PROPERTIES—ADIPRENE L also resists the action of lubricating oils, greases, and automotive fuels. It can be used where salt solutions or dilute mineral acids and bases are encountered at room temperature. ADIPRENE L shows good resistance to oxygen, ozone and radiation, and will perform for long periods at 212° F. (up to 250° F. for shorter periods).



LOAD BEARING CAPACITY of hard ADIPRENE L compounds (shaded area of curve) ranges between that of general-purpose rubber and the harder plastics.

For more information, turn to Reader Service card, circle No. 404

What's more important to you

QDP or PDQ?*

Whirlpool Corporation reports: among 598,265 components supplied by Amplex the first 4 months of 1959, there were only 5 rejects!

Quality, Delivery, Price... this Amplex philosophy enables our customers to cut their production and warranty costs.

The "Price" vendor with poor quality will increase your costs.

Amplex prices are low but cost-saving quality always comes first. A quality record of 99.999992% is the reason why Whirlpool Corporation says, "Quality is our business, too. That's why we purchase components from Amplex."

Contact your local Oilite® representative today. Reduce your costs with quality-controlled Oilite Precision Parts and Bearings. See "Bearings" in the Yellow Pages or write to Dept. T-7.

* *Quality-Delivery-Price vs. Price-Delivery-Quality*

® Only Chrysler makes Oilite

SINCE 1929 — A CHRYSLER PRODUCT — OILITE

the most trusted name in powder metallurgy!

AMPLEX DIVISION

CHRYSLER CORPORATION, DETROIT 31, MICHIGAN

PRECISION PARTS • SELF-LUBRICATING BEARINGS • METAL FILTERS • FRICTION UNITS

For more information, turn to Reader Service card, circle No. 495

DRIVER-HARRIS manufactures the World's Largest Variety of Electron Tube Alloys for

This fact is of the utmost importance to every engineer engaged in the design and manufacture of tubes with greater reliability regardless of size.

Whenever tube engineers needed alloys of particular characteristics for cathodes, plates, grids, seals, etc., D-H has developed the proper metal compositions to meet their specifications.

Through vacuum melting and other types of close analysis control techniques, D-H research continues at an accelerated rate to improve the reliability of melt-approval techniques.

This is the reason for the great diversification of D-H electronic alloys . . . the reason why so many engineers turn to Driver-Harris for the production of the exact special-purpose alloys they need.

Prominent alloys of this group are: Nichrome*, Karbomet*, Gridnic*, Therlo*, 499, 599, 152 Alloy, 142 Alloy, 146 Alloy and INCO Alloys 220, 225, 330.

Now several of these are supplied *exclusively vacuum melted;* others can be on specification. In all there are now over 132 D-H alloys available for electronic and electrical applications. If your alloy need cannot be satisfied by any of these, send us your specification and depend on it . . . Driver-Harris will produce it.

*T.M. Reg. U.S. Pat. Off.

CATHODE SLEEVES

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GLASS SEALING ALLOYS

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SIDE RODS

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MAKERS OF THE MOST COMPLETE LINE OF ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING INDUSTRIES

SPECIAL PURPOSE ALLOYS SINCE 1877 — D/H — TRADE MARK REG. U. S. PAT. OFF.

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YOU DON'T HAVE TO BABY CARMET CARBIDE TOOLS

—on short or long runs!

A full range of Carmet Carbide cutting tools are available to answer every cutting need . . . and allow you to cut with profit. The Carmet Carbide Tips are carefully brazed to alloy steel shanks, strong, tough and beefed up in design to support the carbide.

Full guidance in selecting the proper grade, assistance in selecting the proper tool, is available locally from your Carmet Distributor. He stocks a full line, is there to serve you. Call on him or the Carmet Service Engineers whenever they can help. Carmet Division, Allegheny Ludlum Steel Corporation, Detroit 20, Michigan.

USE THIS CARMET GRADE SELECTION CHART

. . . then machine at optimum feeds and speeds

Carmet Grade	Application	Industry Designation
CA-3	For heavy machining of cast iron and nonferrous material. 300 series stainless.	C-1
CA-4	Machining cast iron and nonferrous material. 300 series stainless.	C-2
CA-604	High Velocity finishing.	C-8
CA-605	Precision boring steel. Light, fast cuts.	C-8
CA-606	Light, fast machining on steel, stainless and high temp. alloys.	C-7
CA-608	Light to medium-heavy machining on steel.	C-7
CA-610	General machining on steel. Heavy roughing cuts.	C-6

WBW 7332 A

FREE NEW CARMET CATALOG

This 32-page first edition contains prices and complete specifications on Carmet's full line of cemented carbide tipped tools, Indexable Inserts, blanks and holders. Speed and feed charts, grade comparisons and ordering information included.

ADDRESS DEPT. MM-19

CARMET

CEMENTED CARBIDE DIVISION OF
ALLEGHENY LUDLUM STEEL CORPORATION

AL

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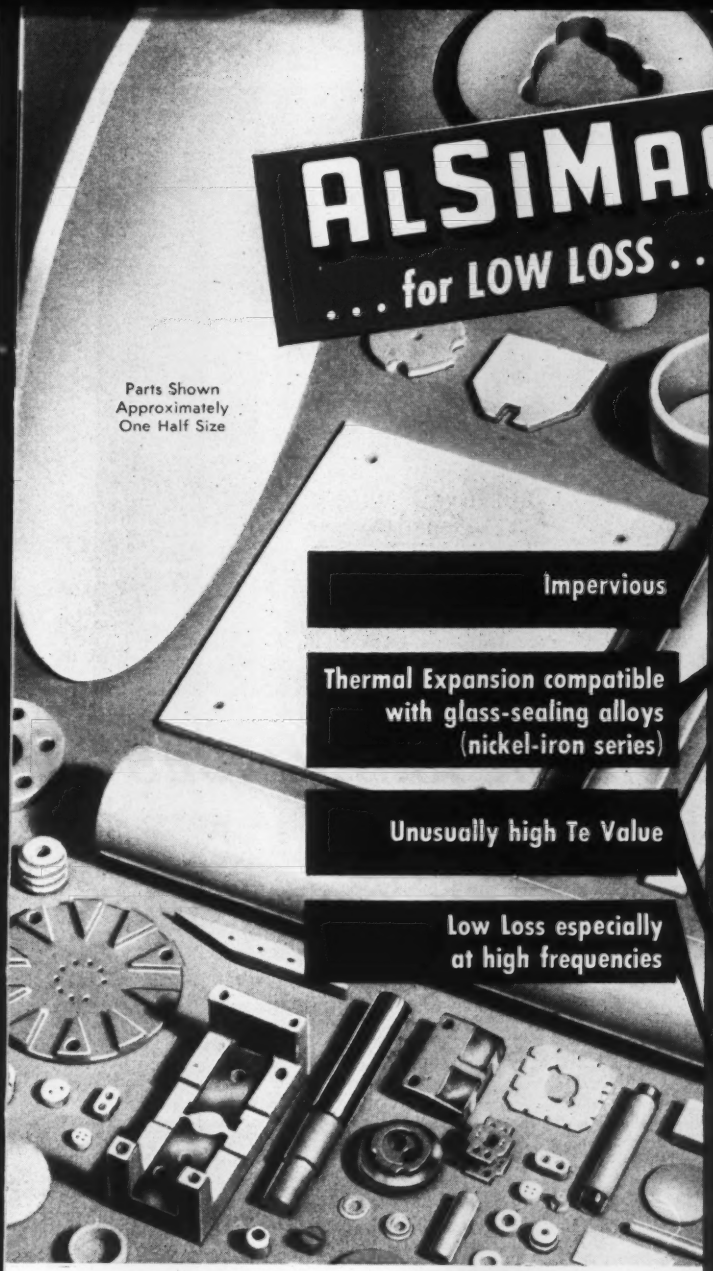
ALSIMAG 243

. . . for LOW LOSS . . . for HERMETIC SEALING



Parts Shown Approximately One Half Size

Impervious

Thermal Expansion compatible with glass-sealing alloys (nickel-iron series)

Unusually high Te Value

Low Loss especially at high frequencies

Note These Advantageous Properties

PROPERTY	UNIT	AlSiMag 243
Water Absorption	%	0 to .02 Impervious
Specific Gravity	———	2.8
Density	Lbs. per cu. in.	.101
Standard Body Colors[a]	———	Buff
Softening Temperature	°C. °F.	1 440 2 624
Safe Temperature at Continuous Heat	°C. °F.	1 000 1 832
Hardness	Mohs' Scale[b]	7.5
Thermal Expansion Linear Coefficient	Per °C. 25-300°C. 25-700°C.	10.0×10^{-6} 11.2×10^{-6}
Tensile Strength	Lbs. per sq. in.	10 000
Compressive Strength	Lbs. per sq. in.	85 000
Flexural Strength	Lbs. per sq. in.	20 000
Resistance to Impact (½" rod)	Inch-Lbs.	4.0
Thermal Conductivity[c] (Approximate Values)	g. cal. x cm. thick cm^2 x sec. x deg. C.	.008
Dielectric Strength (step 60 cycles) Test discs ¼" thick	Volts per mil	240
Volume Resistivity at Various Temperatures 25°C.	Ohms per centimeter cube	$>10^{14}$
100°C.		5.0×10^{13}
300°C.		7.0×10^{11}
500°C.		1.2×10^{10}
700°C.		1.0×10^{8}
900°C.		3.0×10^{6}
Te Value[d]	°C. °F.	>1 000 >1 832
Dielectric Constant[e] 60 Cycles	———	6.3
1 MC.		6.2
100 MC.		6.1
10,000 MC.		5.8
Power Factor[e] 60 Cycles	———	.0014
1 MC.		.0004
100 MC.		.0003
10,000 MC.		.0010
Loss Factor[e] 60 Cycles	———	.009
1 MC.		.002
100 MC.		.002
10,000 MC.		.0058

The low loss, Te value and thermal expansion characteristics of Forsterite ceramics are not equalled by any other impervious ceramic. This is especially important when high frequencies or sealing to metals or glasses is involved.

These properties have created a steadily increasing demand for AlSiMag 243. In the past two years major improvements have been made on this material and its fabrication. We are now producing components formerly unattainable in this material and the number of applications is constantly increasing.

If your application requires the favorable characteristics of AlSiMag 243, why not send us your blue prints and outline your operating conditions? If it is possible that your requirements can be met, we will be glad to work with you at reasonable cost on prototypes for your practical tests. Test discs approximately 1/2" x 3/32" are available with our compliments.

A Subsidiary of Minnesota Mining and Manufacturing Company

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENN.
58TH YEAR OF CERAMIC LEADERSHIP

For service, contact American Lava representatives in Offices of Minnesota Mining & Manufacturing Co. in these cities (see your local telephone directory): Boston: Newton Center, Mass. • Chicago: Bedford Park, Ill. • Cleveland, O. • Dallas, Texas • Los Angeles, Cal. New York: Ridgefield, N. J. • Philadelphia, Pa. • St. Louis, Mo. • St. Paul, Minn. • So. San Francisco, Cal. • Seattle, Wash.
All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

THE 3M CHEMICAL DIVISION ANNOUNCES

fluorel*

BRAND ELASTOMER

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS

New fluorinated synthetic rubber offers top performance in contact with oils, fuels, solvents, acids at temperatures over 400°F. and under some service conditions at temperatures up to 600°F. And it's particularly easy to process and mold.

Even at extreme temperatures, FLUOREL Elastomer maintains excellent resistance to compression set. Approaching 600°F, elongation and hardness do undergo a slight change. Yet, no matter how hot it gets, FLUOREL Elastomer will never support combustion.

On the other end of the temperature scale, at – 50°F. thin sections may be bent.

As well as being highly resistant to corrosive fumes and many fluids even when they're blistering hot, FLUOREL Elastomer shows no change after one year's exposure in a heavy industrial atmosphere. Ozone resistance? No cracking after 200 hours' exposure at 150 ppm by the bent loop method.

FLUOREL Elastomer exhibits electrical properties comparable to those of electrical grade vinyl chloride polymers. That's indicative of good performance, but specific data is yours for the asking.

To complete the property picture: FLUOREL Elastomer is moderately resistant to gamma radiation emitted by Cobalt 60.

EASY TO PROCESS—Besides being easy to process on conventional equipment, FLUOREL Elastomer is easy to compression mold and extrude, and it can be bonded to most metals with adhesives.

No doubt about it! FLUOREL Elastomer is an important newcomer to the ever-expanding family of 3M organic fluorine compounds. It's the direct result of the same pioneering know-how and research that have made 3M a leader in the chemical industry. Following the tradition of its many predecessors, FLUOREL Elastomer should greatly extend the performance range of applications requiring elastomeric materials.

APPLICATIONS—FLUOREL Elastomer is now either in use or under evaluation in the missiles and aircraft, automotive and chemical processing industries for oil seals, "O" rings and gaskets. Tests and field reports are encouraging and suggest other applications as yet untried, such as fire walls, air ducts, fuel cells, fuel and hydraulic hose, diaphragms and tank linings.

For complete data, at our expense, write: 3M, Chemical Division, Dept. KAR-79, St. Paul 6, Minnesota.

**The term FLUOREL is a trademark of Minnesota Mining and Manufacturing Company.*

CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

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ARMCO STEELS / for better products—lower costs

Armco PH 15-7 Mo Stainless Steel Selected for the B-70 and F-108

Combination of high strength, heat and corrosion resistance makes this Armco Stainless grade useful for wide range products; key metal in 2000 mph aircraft developed by North American Aviation, Inc. for U. S. Air Force.

The B-70 "Valkyrie" bomber and the F-108, Mach 3 manned aircraft designed for 70,000-ft. altitudes, will add powerful long-range weapons to America's air armor. To withstand the heat and stresses of such supersonic speeds, special materials are needed. Armco PH 15-7 Mo has been specified as the primary sheet and foil material for wing, fuselage and control surface honeycomb panels, as well as other key airframe elements.

Selection of the newest member of Armco's widely used family of precipitation-hardening stainless steels for these dramatically-new aircraft demonstrates their utility in modern product design. Wherever high strength and hardness must be combined with resistance to heat or corrosion, Armco's precipitation-hardening grades—17-4 PH, 17-7 PH and PH 15-7 Mo—offer unusual advantages. They are used extensively for chemical processing equipment, valves, springs, bolts, specialty fasteners, shafts and a wide range of applications to produce better products at low cost.

Consider the advantages these special Armco Stainless Steels can give *your* products. Write Armco Steel Corporation, 2629 Curtis Street, Middletown, Ohio, for complete information.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation • Southwest Steel Products

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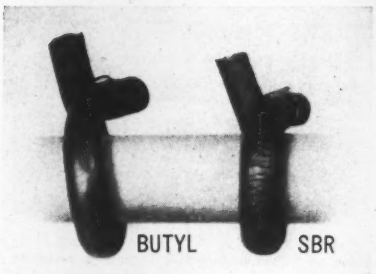
ENJAY BUTYL

FOR RESISTANCE TO SUNLIGHT AND WEATHERING



Butyl's high resistance to ozone is graphically demonstrated when compared with SBR or natural rubber

Enjay Butyl rubber has demonstrated for many years its outstanding ability to resist deterioration caused by sunlight and weathering. This inherent resistance of Butyl to ultra-violet light, ozone, oxidation, moisture and mildew, has made possible many new and colorful products. Butyl has also increased the life of other products such as weatherstrips, protective coating, garden hose, wading pools and many automotive parts.

Butyl *also* offers...outstanding resistance to chemicals, abrasion, tear and flexing . . . superior damping qualities . . . unmatched electrical properties and impermeability to gases and moisture.

For more information call or write the Enjay Company.

ENJAY® BUTYL

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC., *15 West 51st Street, New York 19, N. Y.*

Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

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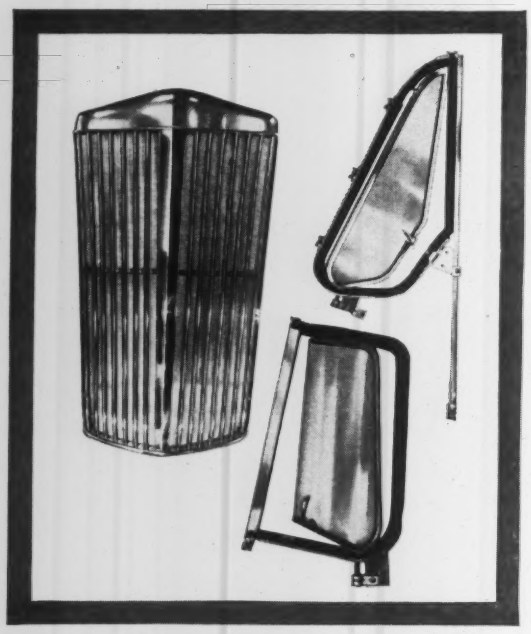
Problem-Solving Products from Republic

FUNCTIONAL STAINLESS STEEL IS CORROSION-RESISTANT, STRONG, WEIGHT-SAVING, READILY FORMED



The high strength-to-weight ratio of stainless steel permits the use of slimmer channels and frames in passenger car and truck sash. Protected by stainless, glass breakage is less likely. Strength, dent-resistance, and corrosion-resistance make stainless ideal for radiator grills. Manufacturer—Excel Corporation, Elkhart, Indiana.

Always right, always bright stainless steel, the optimum metal for trim and brightwork, is showing up in ever-increasing functional applications.

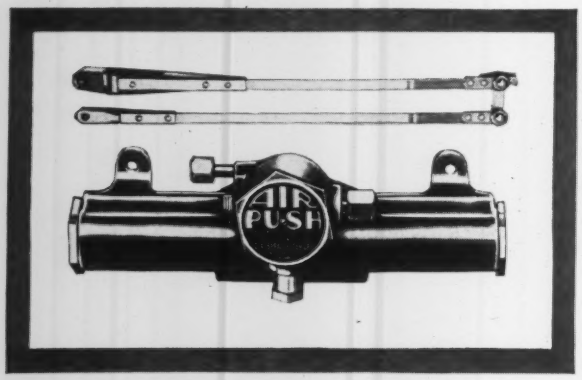
The reason? Stainless steel offers automotive part and equipment manufacturers and designers a combination of qualities unobtainable in any other commercial metal.

Stainless steel parts are tough and strong, yet lightweight. They offer outstanding resistance to heat, wear, and abrasion. They stubbornly resist rust and corrosion. Maintain their great strength through extremes of heat and cold.

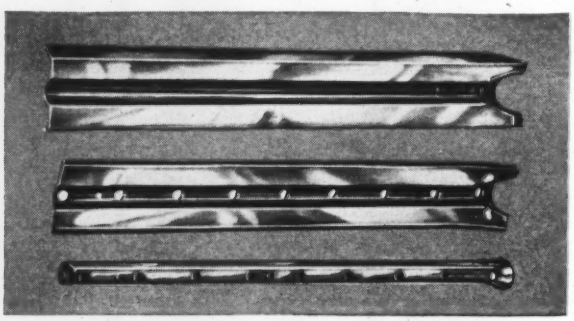
Stainless is readily formed into desired shapes and designs on present equipment with little or no change in procedure and often at lower ultimate cost. Conventional welding techniques, currently in use on production operations, permit the combining of strong, lightweight stainless to carbon steel panels. The result is an over-all reduction in weight without loss of strength or safety, and a structural member that is both functional and decorative.

The functional stainless steel parts and equipment illustrated on these pages represent only a few of many current applications. Others include: mufflers, head gaskets, exhaust manifold butterfly valves, fasteners, heat exchangers. Future applications are practically unlimited.

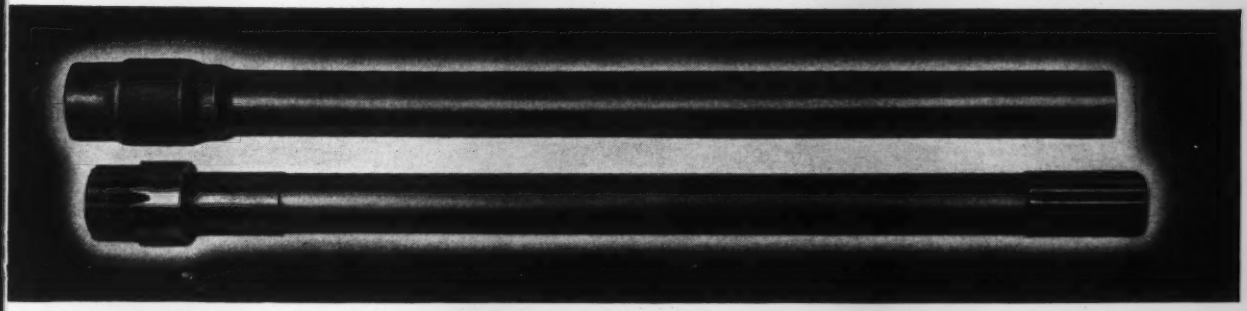
Republic Stainless Steel metallurgists and engineers are always available for consultation on development, selection, application and processing. No obligation for their services. Just mail the coupon.



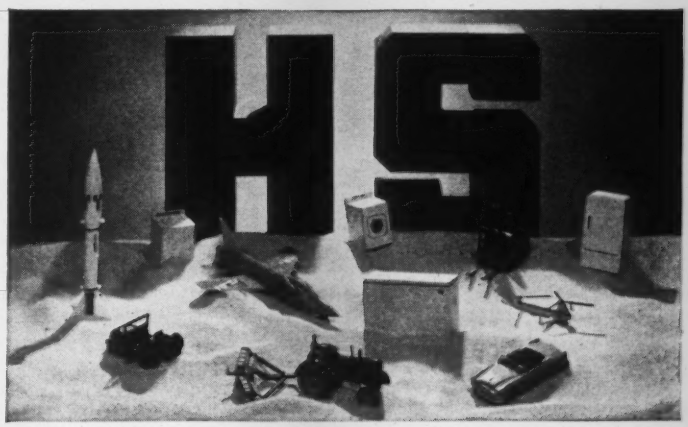
Stainless steel makes an important contribution to the safe operation and maintenance of windshield wipers. Stainless steel's strength assures resistance to breakage or distortion. Light, strong design reduces dead weight that the wiper motor must move. Elasticity of stainless gives the blade the proper pressure on the glass. The wiper arms are protected against the slow and insidious weakening effects of corrosion. Manufacturer—Sprague Devices, Inc., Michigan City, Indiana.



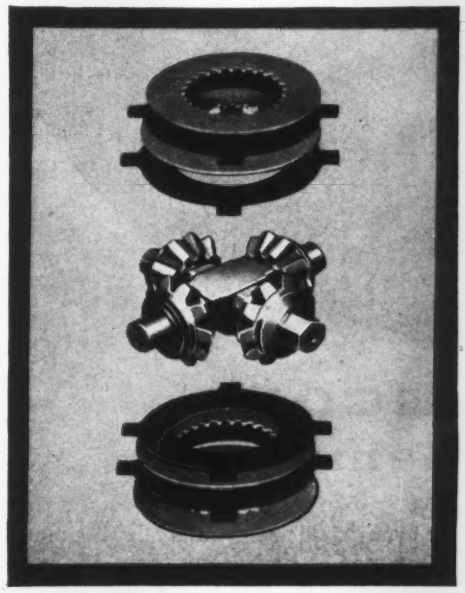
Formability, corrosion-resistance, and cost were prime factors in switching to stainless steel from brass in this engine water distribution tube. Stainless was easily fabricated on existing tools. It took the constant flow of hot water and anti-freeze chemicals in stride. The greater strength of stainless virtually eliminated loss from bent or damaged tubes. Photo sequence shows fabricating operations: (1) Blank of .010″ stainless strip after initial drawing and embossing, (2) Same blank after piercing of water outlet holes trimming of flanges, (3) Completed tube after roll-forming and lock seaming. Produced by Pontiac Motor Division of General Motors Corporation.



NEW FABRICATING PROCESS MEANS ECONOMY. Ford Tractor power take-off countershafts cost less to produce using Republic Die-Form blanks, as compared with previous materials. Blank is shown at top, completed shaft below. Die-Form is a new method of cold forming hot rolled carbon, alloy, or stainless steel bars into multi-diameter blanks ready for final machining. Because Die-Form blanks closely approximate the completed part, scrap losses are negligible. Improved machinability permits savings through use of higher speeds and feeds. Mail coupon for complete facts.



NEW HIGH STRENGTH POWDER, TYPE HS 6460, opens the way for new applications using sinterings for highly stressed parts. Type HS 6460 can be used with existing operating equipment. It provides a minimum tensile strength of 60,000 psi at 6.4 density as sintered, 100,000 psi heat treated. Type HS 6460 maintains its dimensional characteristics after sintering—less than .004 inches per inch shrinkage from die size at 6.4 density. Available in production quantities up to and including 12 tons, or in multiples thereof. Mail coupon for technical data sheet.



SUPER TOUGHNESS AND STRENGTH at critical points are provided by Republic Alloy Steels in the Powr-Lok Differential developed by the Dana Corporation, Toledo, Ohio. Dana engineers have reduced the possibility of mechanical breakdown in clutch rings and side gears to an absolute minimum by forging these parts from Republic Hot Rolled 8615 Alloy Bars. This fine steel offers superior strength and toughness to withstand torque, fatigue, shock, and stress. Uniform response to heat treatment gives the parts hard surfaces around tough cores providing maximum resistance to abrasion, friction, and wear. An exceptionally high strength-to-weight ratio permits the designing of thinner sections to save weight and hold down size. Send coupon for full facts.

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REPUBLIC STEEL CORPORATION
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Please send more information on:
☐ Stainless Steel ☐ HS 6460 Powder
☐ Die-Form ☐ Alloy Steels

Have a metallurgist call
☐ Stainless ☐ Alloy ☐ Metal Powder

Name_____ Title_____

Company_____

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Colonial

can solve *your* SILICONE RUBBER parts problems, too . . .

Molded from various formulations of silicone rubber, these industrial rubber parts were compounded to meet the design engineer's specifications precisely. They are components of various products from home appliances to super-sonic planes, and are typical of the work we do here at Colonial Rubber Company. Check us today on your molded rubber parts requirements. We regularly compound silicone rubber parts for:

Heat Resistance	**up to 600 deg. F.**
Cold Resistance	**down to —135° F.**
Chemical Resistance	**over 600 deg. F. range**
Dielectric Properties	**as required**
Strength Combinations	**shear, tensile, elongation**

Whether you need compound development, parts production or both, contact us. We have a long background of industrial rubber experience, plus complete laboratory and production plant facilities to meet your "toughest" rubber parts requirements quickly, dependably and **economically.**

Write for our brochure . . .

Contains complete, illustrated details on Colonial's **custom** rubber compounding and molding service. No obligation.

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COLONIAL RUBBER CO.
RAVENNA, OHIO

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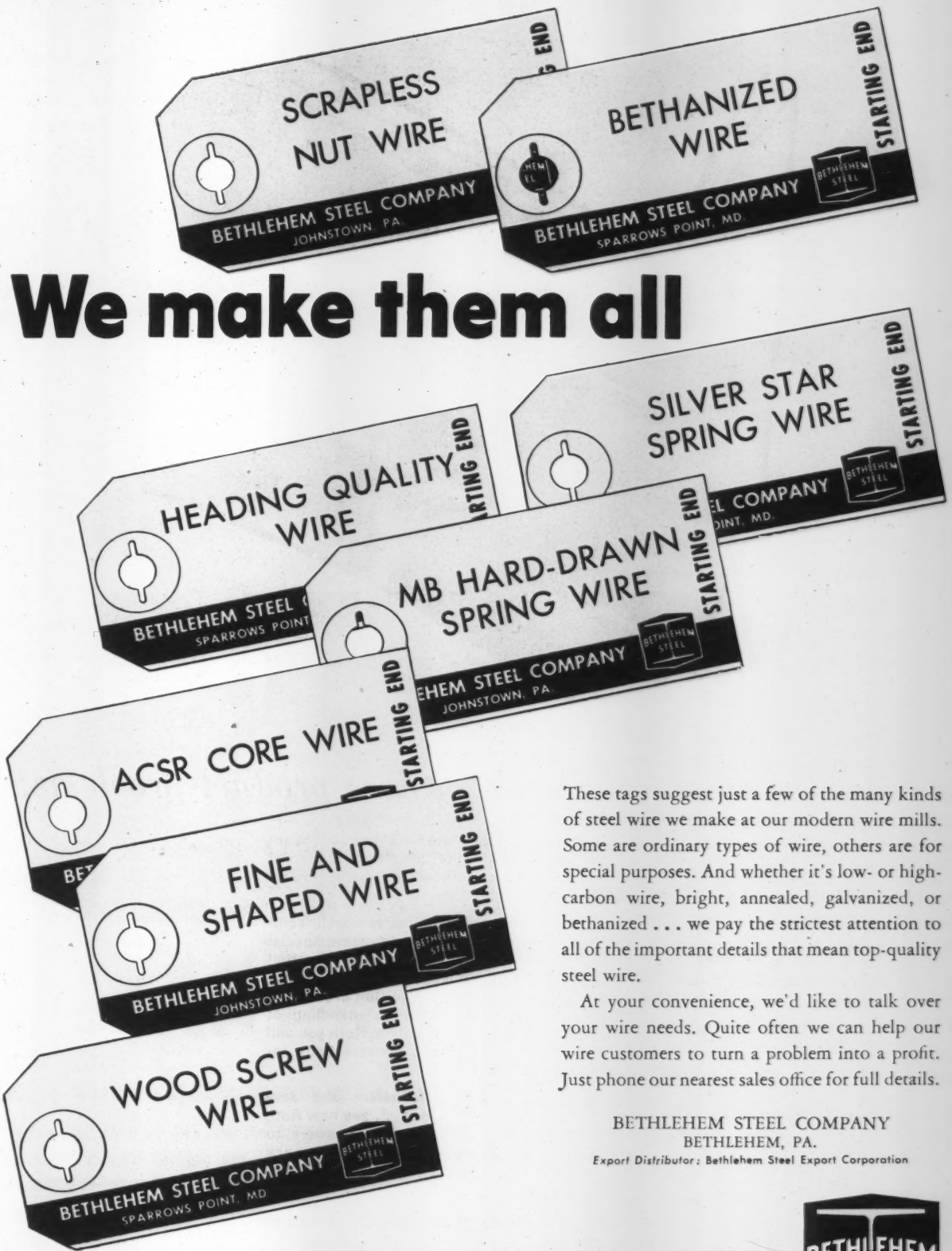

These tags suggest just a few of the many kinds of steel wire we make at our modern wire mills. Some are ordinary types of wire, others are for special purposes. And whether it's low- or high-carbon wire, bright, annealed, galvanized, or bethanized . . . we pay the strictest attention to all of the important details that mean top-quality steel wire.

At your convenience, we'd like to talk over your wire needs. Quite often we can help our wire customers to turn a problem into a profit. Just phone our nearest sales office for full details.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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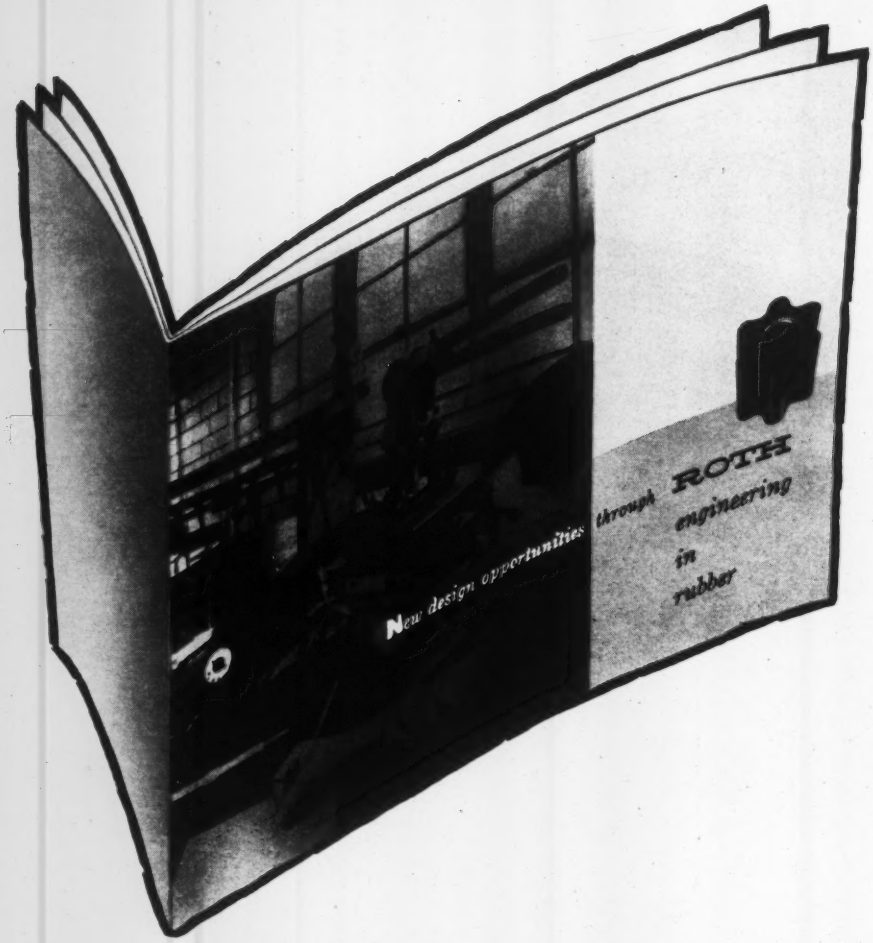

See how "Custom Rubber" solves product problems!

Need a better material for a problem product? Want to cut costs? Boost service life? Here's a new booklet with some eye-opening facts about molded rubber . . . *custom-formulated* by Roth.

At Roth you will find the specialized research facilities and engineering skills needed to create special rubber for specific applications. You will also find advanced molding techniques and modern manufacturing facilities, required for precision production of molded parts, speedy, economical handling of large or small runs. More important—at Roth you will always encounter wholehearted, conscientious interest in your problems.

Send for this authoritative new booklet. See idea-suggesting uses of custom rubber . . . see how Roth Rubber Specialists can help you find answers to material selection problems. Ask today for your copy of "New Design Opportunities through Roth Engineering-in-Rubber."

ROTH

RUBBER COMPANY

1860 S. 54th Ave., Chicago 50, Ill., BIshop 2-1060

Division of Vapor Heating Corporation

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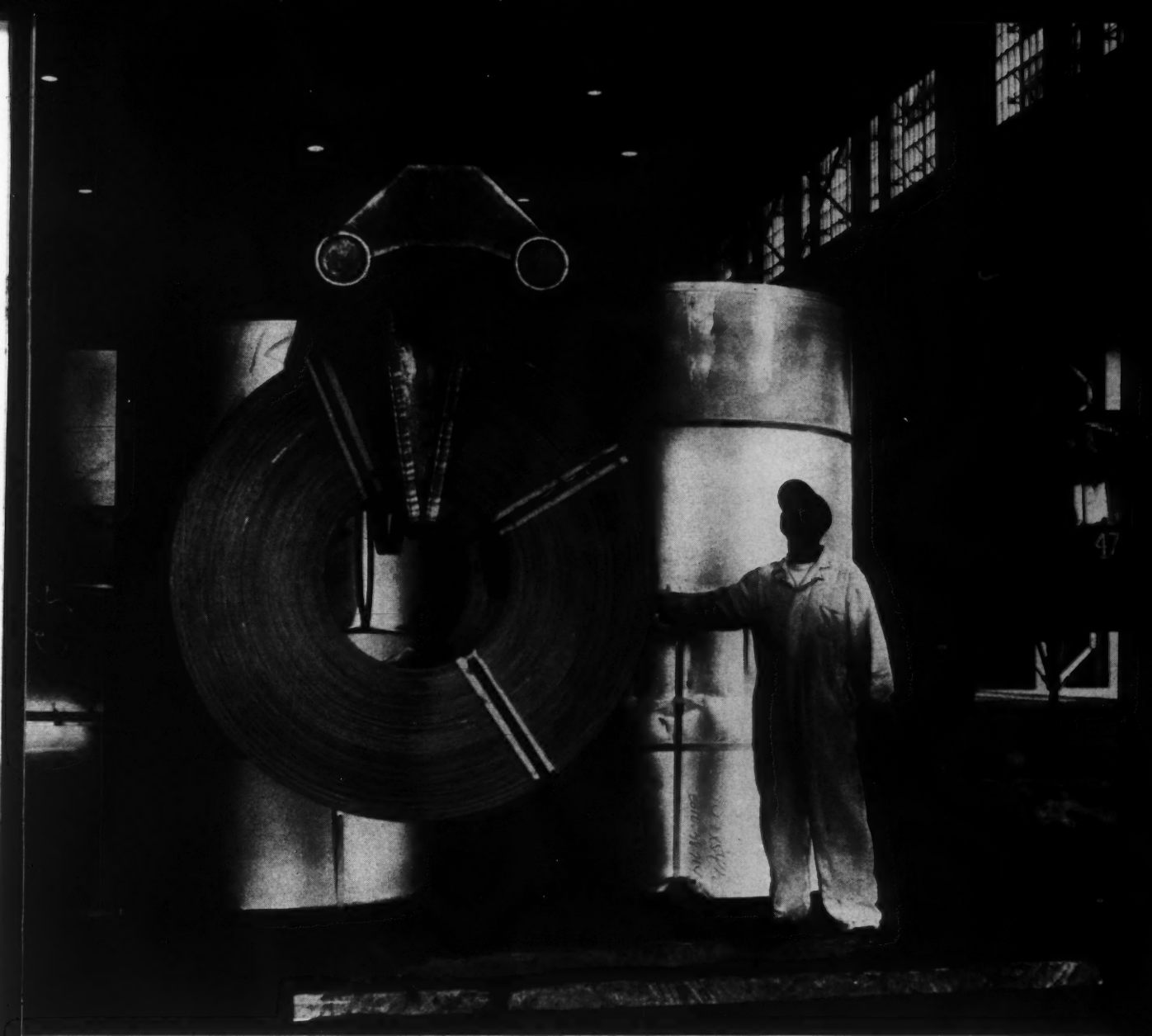

INSTANT STEEL

A CALL TO YOUR LOCAL STEEL DISTRIBUTOR ENDS IN-PLANT SHORTAGES FAST!

Emergency? Your steel service center can end it in a hurry with practically any amount, quality, size or shape of steel you may need. No more in-plant steel shortages—no more plant shutdowns—no more lost contracts.

Or you may choose to use his facilities, stocks and fast delivery service on a regular basis. Whatever your production needs, your local steel distributor is on hand ready to give instant service. All you have to do is phone.

Call him for any quantity of Weirkote continuous-process zinc-coated sheets, Weirzin electrolytic zinc-coated sheets, hot- or cold-rolled sheets or any type of steel you may need for any type of production job.

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

NATIONAL STEEL CORPORATION

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DOW | MAGNESIUM PRODUCTS

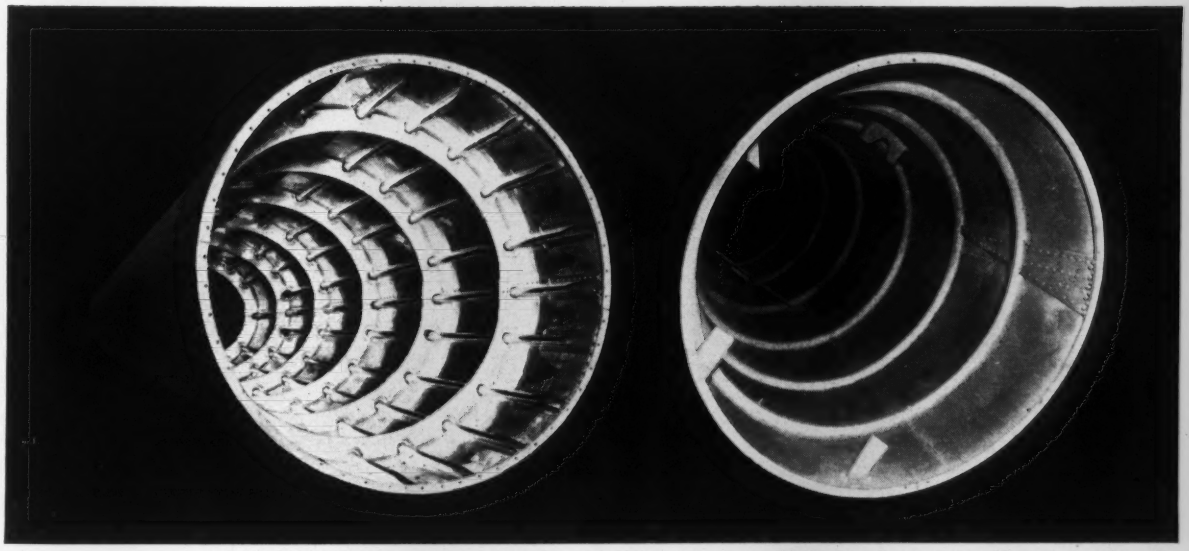
LIGHTWEIGHT DESIGNS

save more than weight

Designers reap a rich harvest of additional benefits as a result of lightness when they use magnesium. Bonuses such as more payload, simplified design, increased performance and reduced human exertion.

People who buy and use the luggage pictured above derive a very direct benefit from magnesium. As this lightweight luggage is made of magnesium, it saves human effort and fatigue. Also, the reduction of weight means more luggage can be carried without extra charge when traveling by air. Magnesium saves human exertion in other products, such as ladders, power tool housings and materials handling equipment.

Another example of the many savings and extra benefits that magnesium—and its resultant load lightening make possible for the designer is in the automotive field. One delivery truck unloads its last parcel and heads for the garage and the gas pump. Another, of identical size, goes on to deliver many



SIMPLIFIED DESIGN in magnesium aircraft part (right) was made possible by its advantageous stiffness-to-weight ratio.

more lbs. of merchandise. Why? The second truck is much lighter—its body is made entirely of magnesium alloy sheet, plate and extrusions. *Because* the second truck is lightweight, it can carry more payload. Or, it can carry the same payload as the first with less fuel, smaller tires and less wear and tear on the engine and transmission. Lighter trucks also save their owners money on license fees, insurance premiums and over-all maintenance.

An even more dramatic example is that of missile design. In one ballistic missile, the elimination of *one pound* of excess weight contributes approximately 18,000 feet of additional altitude and a comparable increase in range! This means vastly improved performance wherever magnesium can be substituted for heavier materials.

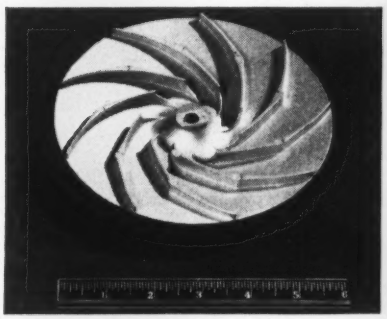
MAGNESIUM LIGHTNESS INCREASES STRENGTH, STIFFNESS

The designer who is seeking a stiff section can achieve it easily—and still save weight—with magnesium alloys. Magnesium weighs only 67% as much as aluminum, 25% as much as steel and zinc. A structure made of magnesium could be 8 times as stiff as the same part in steel if designed to equal weight. If equal stiffness is the design criterion, a magnesium section can weigh 62% less than steel and 25% less than aluminum.

Aircraft manufacturers have learned to exploit these facts to the fullest in conserving precious airborne weight. Critical parts such as wing and tail structures can be designed with more than adequate stiffness for high speed flying conditions. And, in addition to weight savings, magnesium helps provide a smooth aerodynamic surface and reduces "flutter" and "drag". Most important, the use of more rigid magnesium sections simplifies design by eliminating many of the stringers and stiffeners necessary with other materials.

★ ★ ★

WRITE TODAY for new brochure, "Magnesium Design". For your copy of this valuable reference for designers, contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Products Sales Department 1342CD7.



22,000 r.p.m. HOUSEHOLD ITEM

This die cast vacuum cleaner fan must rotate at 22,000 r.p.m. and have low starting inertia as well as high centrifugal strength. Only magnesium was able to meet the requirements of this specific design. Casting tolerances are held so closely there is no need for balancing.

WORKER FATIGUE THWARTED

A prominent automotive manufacturer uses magnesium paint shields in spraying speedometer panels. The weight saving compared to previous shields resulted in less fatigue, higher efficiency for women employees. The excellent alkali resistance of magnesium permits easy removal of dried paint.

DOW PRODUCTION FACILITIES

The Dow Madison, Ill. mill rolls flat sheet and plate and coiled sheet. It also provides extrusions up to 30" circumscribing circle. The Dow Bay City plants produce high quality sand, permanent mold and die castings as well as lightweight magnesium fabricated assemblies. And, you get Dow experience and technical service in addition.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

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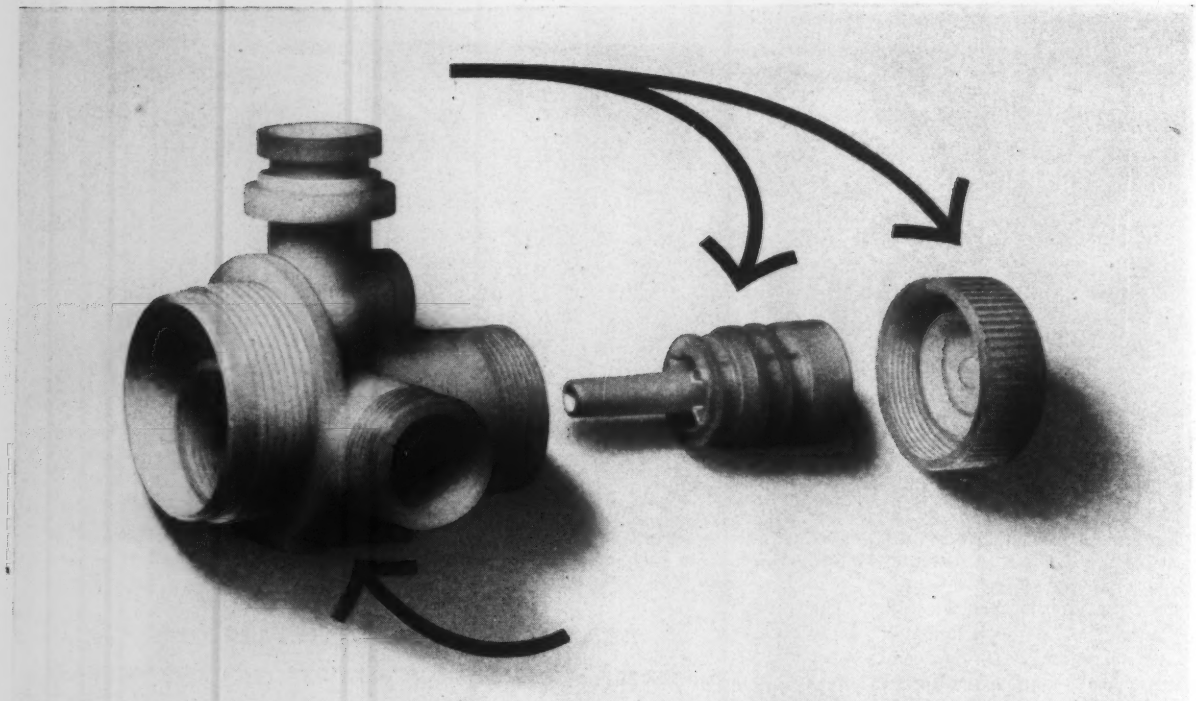


Chicago Molded parts improve performance, cut costs 3 ways

These molded nylon parts compose a unique Venturi valve unit used to regenerate the mineral bed of the Culligan Automatic Water Softener. Previous valve bodies were brass. By switching to injection molded thermoplastics, performance and durability were improved . . . material cost cut, machining and finishing eliminated. To function properly, exacting tolerances were vital. And the valve's $\frac{3}{8}$" diameter outlet had to be formed without parting lines—inside and out. Any irregularity would harm the Venturi system vacuum. We had the answer, and production capacity to mass produce the parts as specified. *Your job* may be smaller or very large . . . may require a different plastic . . . compression or transfer molding. Our forty years of custom molding know-how and a complete range of press facilities can come up with *your* right answer—can recommend the material and method of utmost value to you. Call or write . . . no obligation.

CHICAGO MOLDED
PRODUCTS CORPORATION
1026 North Kolmar Avenue, Chicago 51, Illinois

For more information, turn to Reader Service card, circle No. 403

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

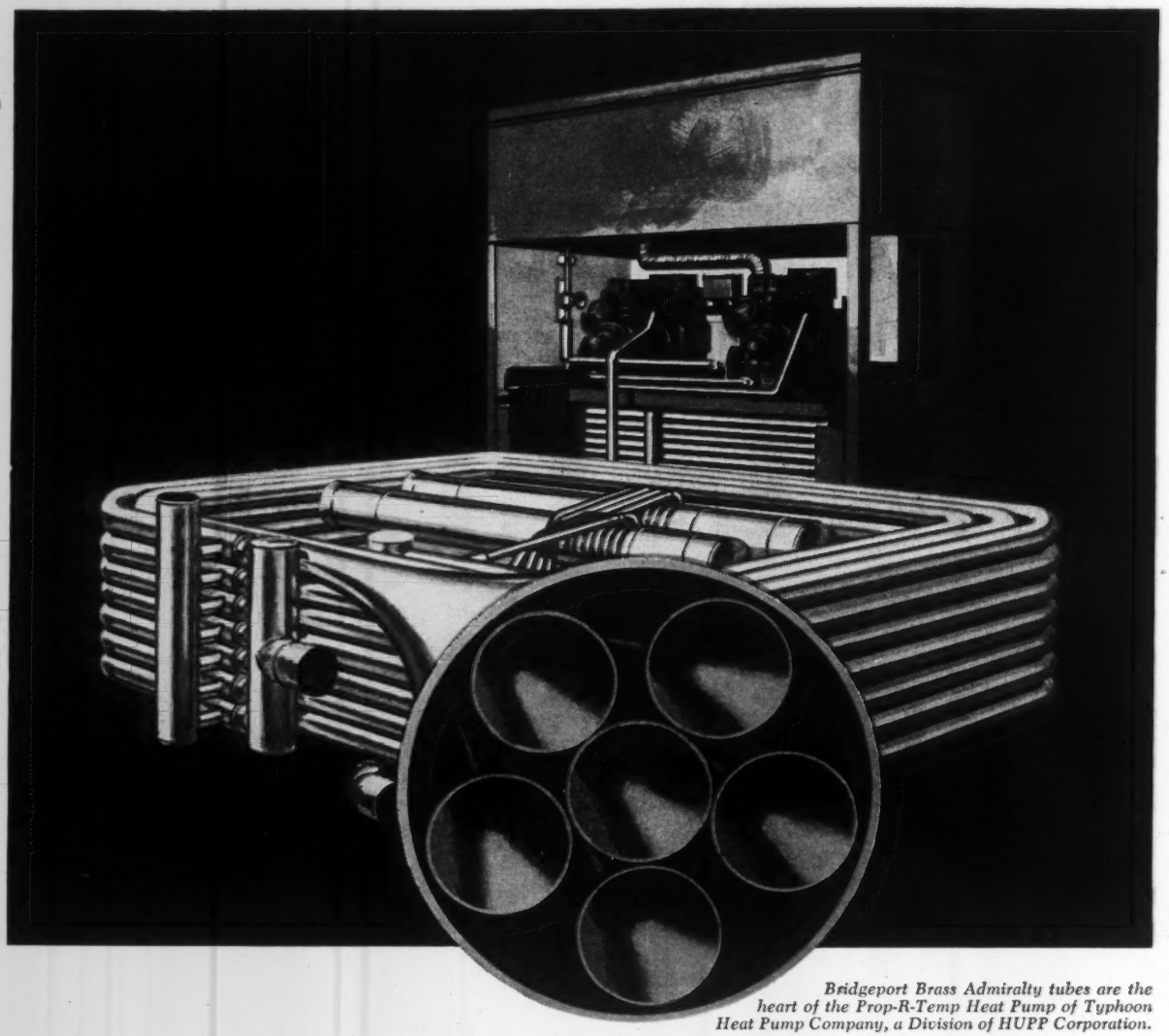
now...Lehigh H leads the field in machinability

As the result of its special annealed structure, developed and tested over a period of several years, Bethlehem's Lehigh H tool steel (AISI Type D-2) now leads the field in machinability among the high-carbon, high-chrome tool steels sold today. In impartial studies, the machinability of Lehigh H has been proved outstanding as a most economical grade for a wide range of difficult applications.

In addition to its better machinability, Lehigh H now has improved wear-resistance, because its vanadium content has been increased to 1 pct. Other important advantages of Lehigh H: improved carbide distribution and increased center density, based on U. S. Patent No. 2,809,109, issued to Bethlehem. Its uniform structure makes possible a better response to heat-treatment, and results in maximum service life for tools and dies, even in the most severe service.

Lehigh H is the D-2 type of air-hardening high-carbon, high-chromium tool steel, which is well known for minimum dimensional change in heat-treatment. For tops in machinability, and for all-around dependability and economy, be sure to order the new improved Lehigh H from your Bethlehem tool steel distributor.

For more information, turn to Reader Service Card, circle No. 472



Bridgeport Brass Admiralty tubes are the heart of the Prop-R-Temp Heat Pump of Typhoon Heat Pump Company, a Division of HUPP Corporation.

HEAT PUMPS PROVE THE DEPENDABILITY OF

This remarkable Prop-R-Temp Heat Pump, a product of Typhoon Heat Pump Company , Tampa, Florida, heats, cools and dehumidifies. A key part of this unit is the tube-in-tube condenser coil which transfers heat from water to refrigerant, or reverse. This unique circular or rectangular coil consists of six ⅜" O D Bridgeport Admiralty tubes nestled inside a larger, 1⅜" O D Admiralty tube. The six smaller tubes are inserted into a straight length of larger tube and then coiled or bent on blocks of various radii. This fabricating method requires closely controlled physical properties of tube to avoid distortion. The length and number of coils—whatever their size—is subjected to a test of 1,000 lbs. pressure before being accepted for application.

Years ago, trouble was frequently experienced due to copper tube failure or excessive scaling caused by highly corrosive waters in certain localities. This failure was costly since,when it occurred, it was necessary to replace the entire condenser.

Bridgeport came up with the answer—Admiralty tubes. Since the switch, over 1,000 Typhoon heat pumps have gone into service without one instance of tube failure due to corrosion in sizes varying up to 1,000,000 BTU's.

Here again is an example of how *standard* Bridgeport alloys overcame *special* fabricating and corrosion problems. It's also an example of why it pays to take advantage of Bridgeport's outstanding metals know-how. Call in the Man from Bridgeport, today. There's a Sales Office near you. Or write to Dept. 3504.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut • Sales Offices in Principal Cities

Specialists in Metals from **A***luminum to* **Z***irconium*

BRASS Bridgeport CO.

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This won't stop corrosion—

but versatile-flexible

TYGON® WILL!

Simply crossing the fingers doesn't help much when it comes to corrosion control. But a sure-fire method—and much more economical in the long run—is to specify Tygon if corrosion is a problem in any product you make. Available in a variety of convenient forms and job-specified formulations, Tygon offers superior resistance to a wide range of acids, alkalies, salts, alcohols, oils and solvents.

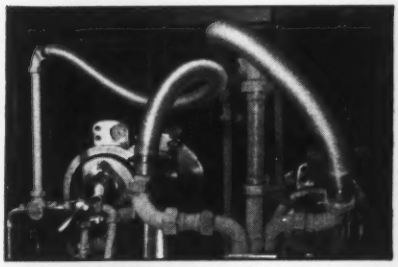
CHECK THE WAYS TYGON CAN IMPROVE VALUE AND PERFORMANCE OF YOUR PRODUCT

AS A COATING

Easily applied by brush, spray, dip or roller-coat, Tygon forms a fast-cure, tough, impermeable plastic barrier that seals out corrosive fumes and acids. Gives equipment longer lasting protection against chemical attack and extreme moisture.

AS LININGS

Tygon Sheeting offers heavy-duty protection against corrosive solutions in storage and processing tanks of all shapes and sizes. Easier to install, handles many of the tough jobs rubber and other linings cannot do.

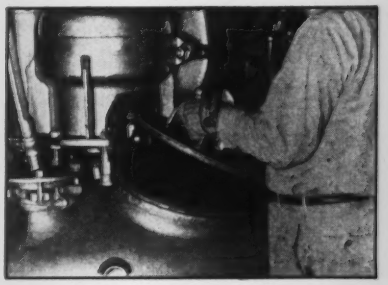


AS TUBING OR HOSE

Flexible, glass-clear Tygon Tubing is ideal for piping flavor-sensitive liquid foods or corrosive chemicals. Non-toxic, non-contaminating, sterilizable. Tough, durable, abrasion-resistant for long service life. Available 1/16" to 4" I.D.

AS GASKETING

Tough, resilient Tygon Gasketing assures tight, durable, leak-proof sealing. Its excellent chemical resistance eliminates costly corrosion "trouble spots" where other materials fail. Cut from sheet, tubing, solid cord, or molded to your specifications.



OUR 100th YEAR

Write for detailed Tygon Portfolio today—or ask our engineering staff to recommend the proper Tygon formulation for your application.

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

AKRON 9, OHIO

445-F

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HERCULES

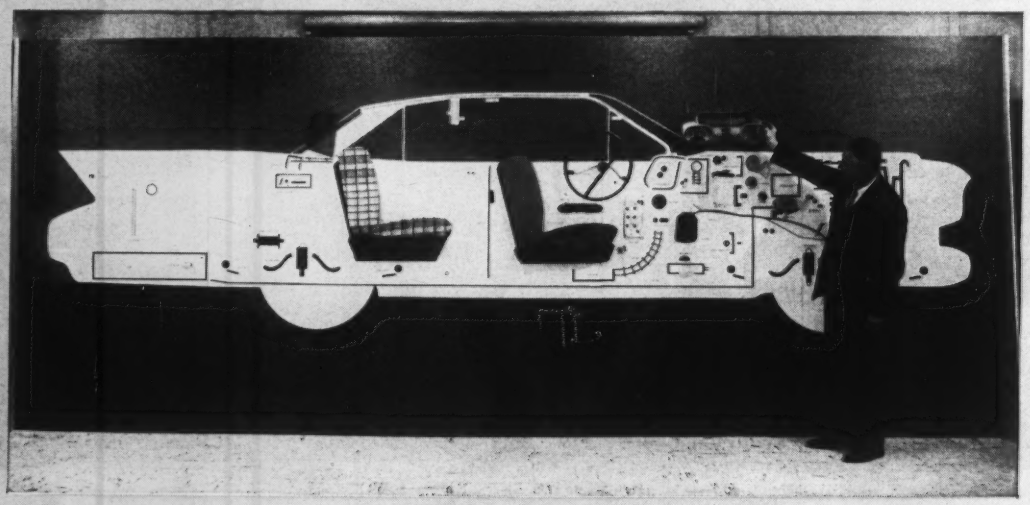
Plastics Hi-lites

The price (and density) is right! 42¢

At its present cost, Pro-fax® is today's biggest bargain in thermoplastics.

Like all new plastics, Pro-fax, Hercules polypropylene, found its early uses in jobs where its unique combination of properties served a special need. Thus uses requiring the outstanding heat resistance of Pro-fax, or its excellent mechanical and chemical properties were among the first to be developed. But by now the word has gotten around: the properties of Pro-fax are only part of the story. Its present price, coupled with a low specific gravity that spells many additional pieces per pound of material, *makes Pro-fax today's biggest bargain in thermoplastics!* Plastics producers in a broad list of markets are finding they can save real money in both resin and processing costs—and at the same time obtain a superior product—by converting to Pro-fax.

Quick to get on the Pro-fax bandwagon have been the large volume producers who supply the auto industry and the appliance markets. Here, where even small savings can add up to big money, Pro-fax has proved itself a truly structural plastic, able to perform well, and at low cost, in a variety of functional uses. On the other hand, the design possibilities of Pro-fax loom large in the thinking of manufacturers of housewares, toys and packaging. Here Pro-fax is now being used in growing volume in products formerly made of wood, metal or glass, to yield better-looking, fast-selling, quality merchandise. And again, the price is right . . . to producer and consumer alike. Take, for example, all the handsome new Pro-fax products shown here.



Right for automotive uses!

Auto builders are switching to Pro-fax for many key uses. This full scale diagram of a modern car shows the location of more than 100 parts made of Hi-fax®, high-density polyethylene, Pro-fax or Penton® chlorinated polyether. Parts now in commercial use or evaluation are mounted in their approximate location on the chart. Projected parts are shown schematically. Call or write for complete information on the use of Hercules plastics in this growing market.

***Right* at home outdoors!** Pro-fax is perfect for housewares, particularly picnic and casual furnishings designed for outdoor use. These handsomely styled dishes, called *Tranquilware* are available in four attractive colors, with a lustrous, durable finish that is completely stainproof, virtually unbreakable, and immune to the detergents and heats of modern home dishwashers. Pro-fax monofilaments used on the outdoor furniture shown in the background are fadeproof and sag-resistant, lightweight, durable, and can't be stained by food or cosmetics.

Tranquil Dinnerware manufactured and sold by Byrd Plastics, Erie, Pennsylvania.

The "Right Touch" in packaging!

Pro-fax packages glamour to perfection in this striking new aerosol container for Coty Spray Cologne. Called *Petite Mist*, it's available in four enchanting fragrances in a choice of two eye-catching color combinations—either jet black or snow white, each richly decorated with gold. Only pennies' worth of Pro-fax, economically formed into this shapely yet functional package, add up dollars' worth of consumer value and merchandising appeal.

Two-piece aerosol package molded by Pyro Plastics, Union, New Jersey.

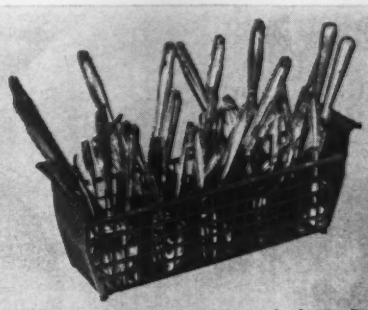
Right . . . light . . . and bright!

Providing outstanding performance and economy in lightweight plastic bottles, Hi-fax is now the standard by which all materials for blown containers are measured. Note the sharp detail of the lettering on this new Hi-fax bottle for Avon Deep Clean Cleansing Cream. It's typical of the dramatic decorative effects possible with this versatile packaging plastic.

Bottles are molded with Hi-fax by Imco Container Corporation, Kansas City, Missouri.

The right fittings for plastic pipe!

Pro-fax solved this tough engineering problem: the development of long-lasting, low-cost fittings for flexible plastic pipe. "Poly-Plus Blue Fittings" now being marketed in a full range of types and sizes by Union Malleable Manufacturing Company in Ashland, Ohio, are as durable as steel or iron, more corrosion-resistant than brass or copper. Lightweight, easy to assemble, and unmatched for serviceability, they extend the usefulness of plastic piping systems, especially when used in combination with new, low-cost Hi-fax pipe.



Puts Silverware in the right place!

This rigid plastic silverware basket for Westinghouse is an attractive new feature in Westinghouse "Roll About" Portable and "Roll Out" Built-In Dishwashers. It's typical of the cost savings combined with product improvement made possible by the use of Pro-fax in modern appliance design. A handsome, sturdy, one-piece unit, highly resistant to heat, staining and corrosion—it can't chip, crack, peel or rust, and is unbreakable. These new baskets, molded by Cleveland Plastics, Cleveland, Ohio, replace parts previously fabricated with metal wire and a plastisol covering, provide greatly increased resistance to wear, with a richly colorful finish impervious to dishwashing chemicals and household greases.

CP59-11

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

HERCULES

THREE NEW MATERIALS FOR THE PLASTIC INDUSTRY

HI-FAX® HIGH-DENSITY POLYETHYLENE • PRO-FAX® POLYPROPYLENE • PENTON® CHLORINATED POLYETHER

For more information, turn to Reader Service card, circle No. 504

brazed successfully with

Millers Falls Router Bits and Dyno-Mite high-speed power bits are revolutionary in concept, design and materials. They both perform with such unmatched efficiency that they have reached the "top-of-the-list" in their field.

Dependable, prolonged service is a "must" for all Millers Falls products and the component parts of both bits are therefore brazed with Silvaloy. The joints are as strong as the high-speed steels they join. Millers Falls uses Silvaloy 45 and Deoxo flux for these operations.

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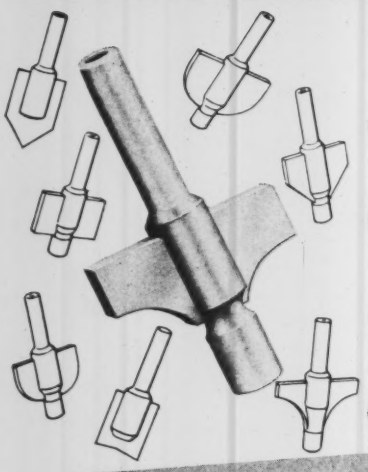

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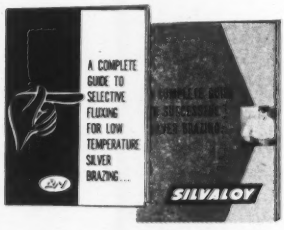

Two complete reference manuals for low-temperature silver brazing and fluxing are available upon request. Send for either one or both. ★ ★ ★ ★ ★ ★ ★

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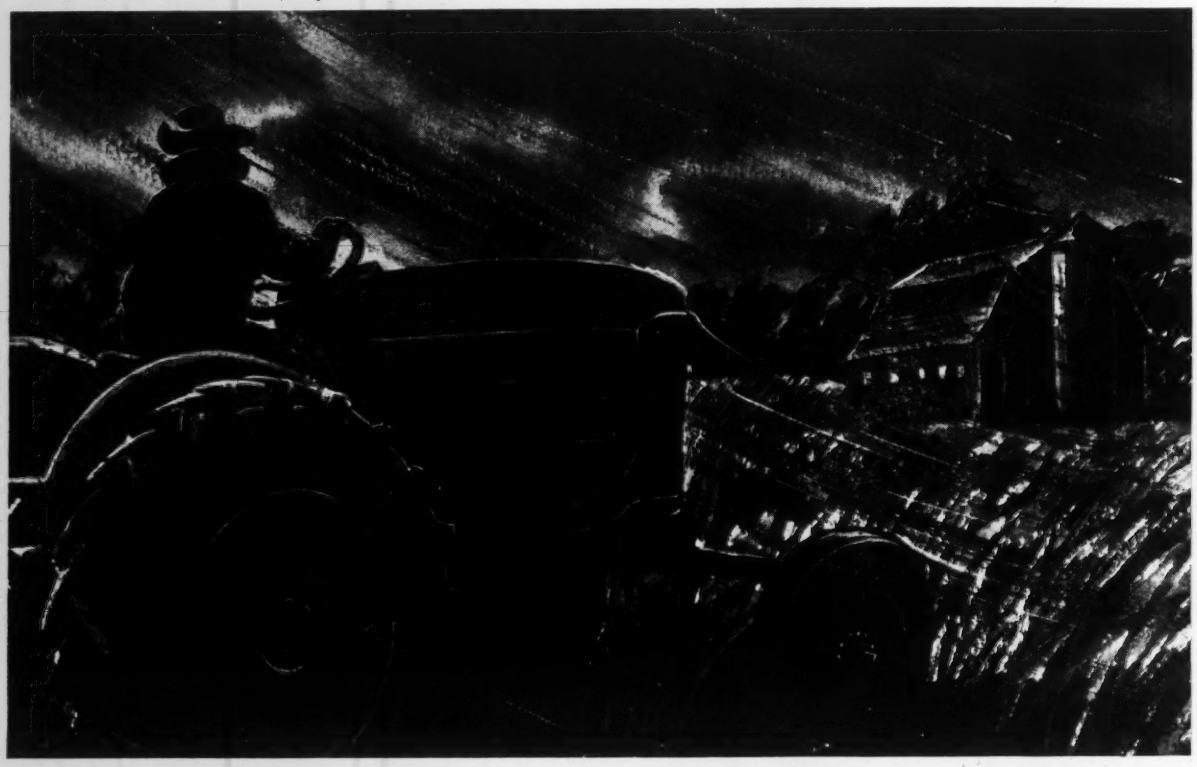

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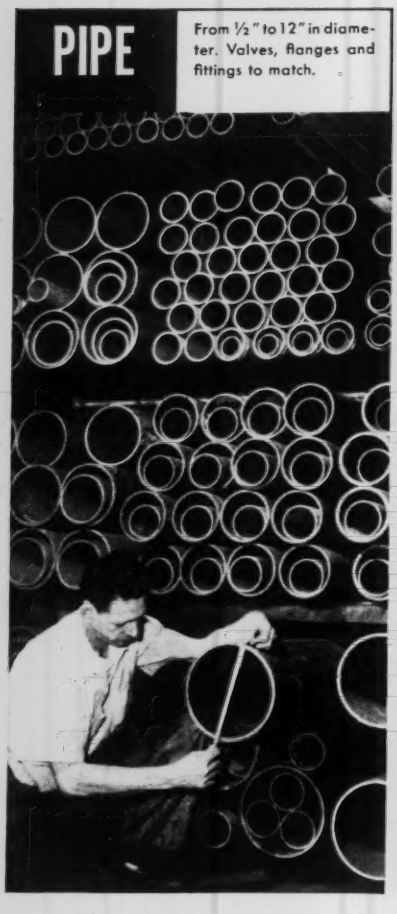

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Portable storage tank *for liquid oxygen takes advantage of the low temperature strength of the 5000 series.*

The New 5XXX Aluminum Alloys– Strong and Weldable

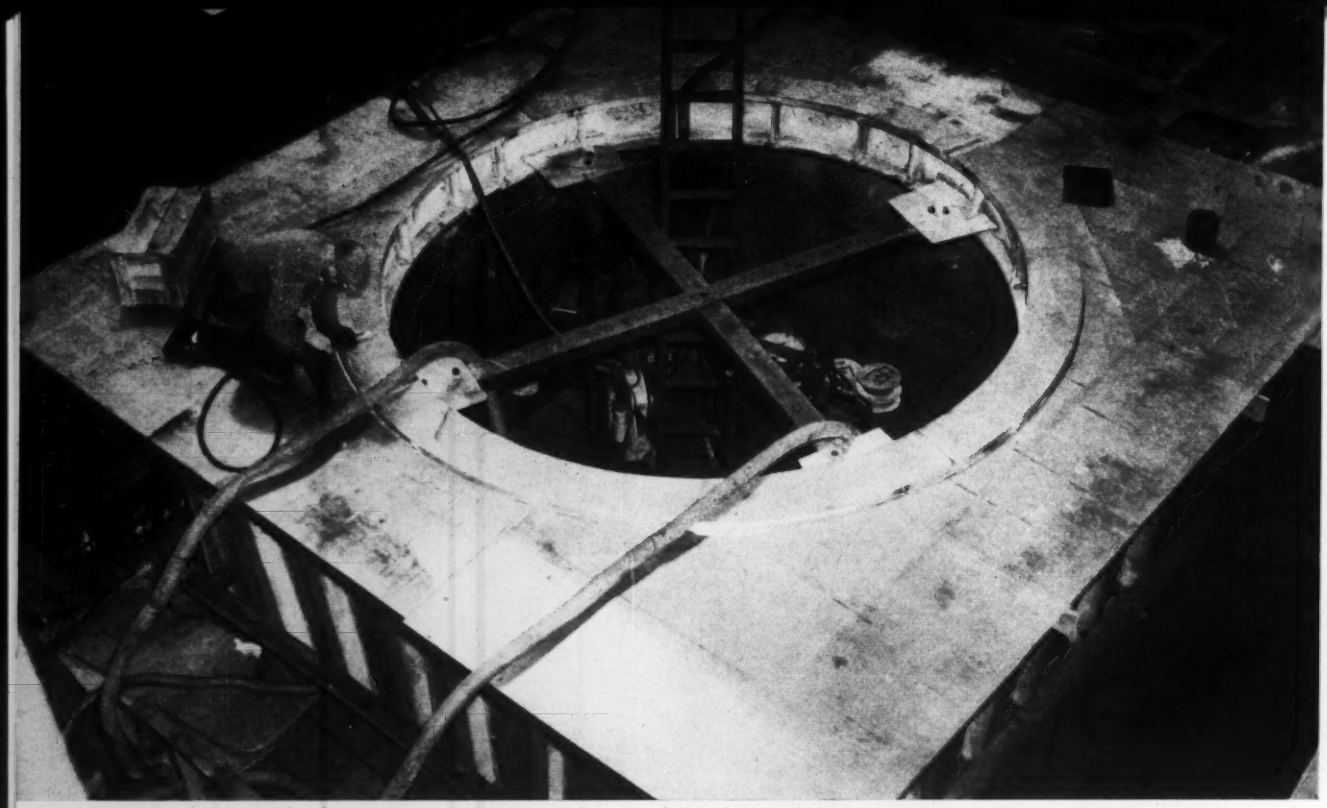
How and where to use a recently developed series of aluminum-magnesium alloys.

by R. T. Myer and D. R. Cheyney,
Kaiser Aluminum & Chemical Corp.

■ The 5XXX series of aluminum alloys is a relatively new group containing 2.5 to 5.5% magnesium and up to nearly 1% manganese that has opened the way to wider economic use of aluminum in heavy-duty applications.

This series includes the strongest non-heat-treatable aluminum alloys. They are readily weldable. Particularly significant are their high annealed yield strengths, which make possible efficient use of welded fabrication methods.

Because of these characteristics, the 5000 series has been used for structural aluminum applications in the marine, transportation, ordnance and process equipment fields. Where lighter weight is a requirement, and/or alumi-



***SOME MORE USES FOR 5000 SERIES ALLOYS: Gun foundations** for destroyers.*

TABLE 1—MINIMUM MECHANICAL PROPERTIES

Alloy	Nominal Comp, %	Temper	Ten Str, 1000 psi	Yld Str (0.2% set), 1000 psi	Elong (in 2 in.), %
Group I					
5052	Mg 2.5, Cr 0.25	O	25	9.5	18
		H32	31	23	11
		H34	34	26	10
		H112	28	—	7
5454	Mg 2.7, Mn 0.8, Cr 0.10	O	31	12	18
		H32	36	26	12
		H34	39	29	10
		H112	32	18	8
Group II					
5154	Mg 3.5, Cr 0.25	O	30	11	18
		H32	36	26	12
		H34	39	29	10
		H112	30	11	8
5086	Mg 4.0, Mn 0.5, Cr 0.10	O	35	14	14
		H32	40	28	12
		H34	44	34	6
		H112	36	18	8
5083	Mg 4.5, Mn 0.6, Cr 0.10	O	40	18	16
		H32[a]	45	34	8-10
		H34[a]	50	39	6-8
		H113	44	31	12
Group III					
5456	Mg 5.1, Mn 0.8, Cr 0.10	O	42	19	16
		H321	46	33	12

[a]Available in sheet thicknesses only.

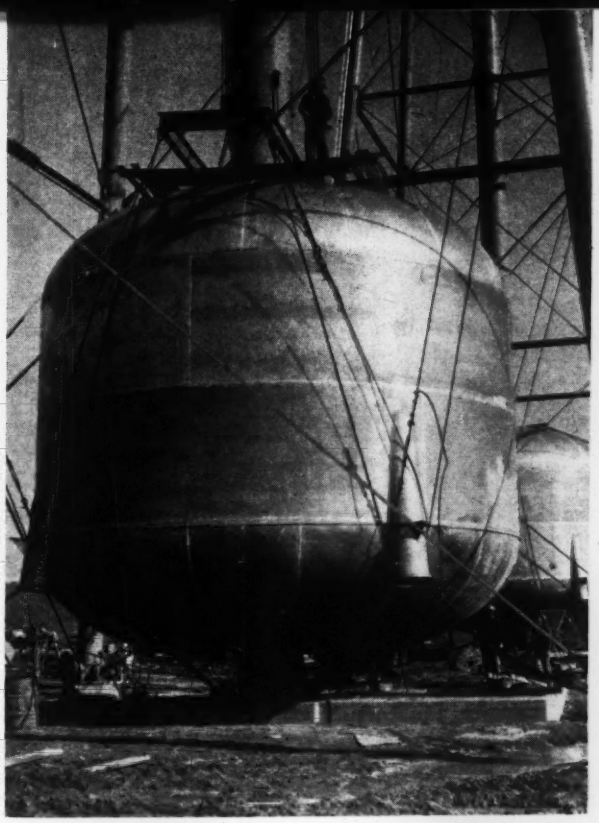
num's corrosion resistance provides longer service life and reduced maintenance, these alloys are competitive with mild steel.

Three groups of alloys—and what they offer

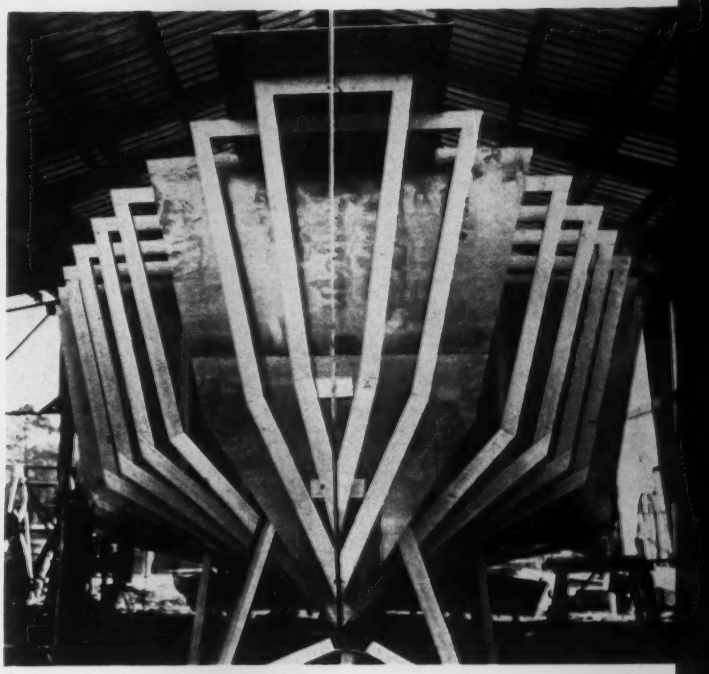
The compositions of the principal alloys comprising this structural series are given in Table 1. Although perhaps not properly a member, 5052 is included for comparison because it has gained a well deserved reputation as a tough, general purpose alloy with exceptional corrosion resistance. This alloy also pointed the way toward the development of the stronger alloys with higher magnesium content.

The alloys can be classified generally into three groups:

Group I—5052 (5152, 5652) and 5454. Alloy 5052 is one of the most serviceable aluminum alloys and is probably used for a wider range of applications than any other aluminum alloy. Of the two modifications of 5052, 5152 has lower purity and 5652 has special impurity controls for use with hydrogen peroxide.



Tanks *for water storage.*



Framing and bulkheads *for tugboat hulls.*

All of the alloys of Group I can be used without a temperature limitation based on stress corrosion. Type 5454 is the highest strength aluminum-magnesium alloy that can be used without this restriction. In addition, all of these alloys provide good workability at low cost.

Group II — 5083, 5086, 5154 (5254). Headed by 5083, this group offers substantially greater strengths than the alloys of Group I, along with resistance to stress corrosion, good general corrosion resistance, and good workability. The 5254 modification of 5154 has special impurity controls for use with hydrogen peroxide.

Because of stress corrosion considerations, these alloys should be restricted to a maximum temperature limit of 150 F.

Group III—5456. This alloy has the highest strength in the 5000 series. It has good general corrosion resistance but is not quite as weldable and formable as the alloys of the other two groups. Under certain circumstances, the alloy should be annealed or stress relieved after forming.

Alloy 5456 must be used with caution if stress corrosion susceptibility is a problem. It should not be used at temperatures above 150 F.

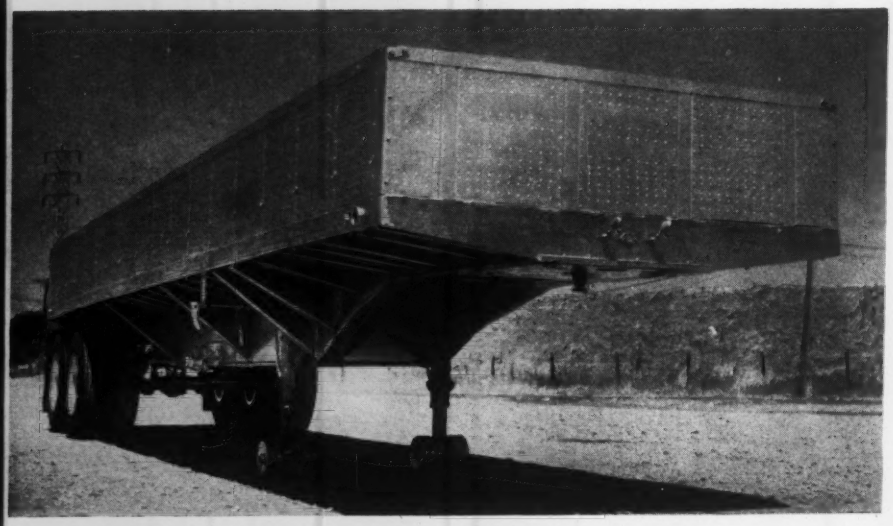
Properties of the alloys

Table 1 lists the major mechanical properties of these alloys and shows that the modified alloys have improved properties. The alloys in Groups II and III are normally selected for structural applications. Most of them are available in extrusions as well as in sheet and plate. Selection of an individual alloy will customarily be based upon the particular requirements of the application. Where lighter gages are used, Group II alloys are generally preferred over Group III.

Weldability

Processes for welding the 5000 series are discussed in an accompanying box. Selection of the particular arc welding method depends largely on the individual application. However, the TIG process is preferred for welding aluminum sections less than ⅛ in. thick. This method can also be used for heavier sections, but the

Cone and head sections *of ready-mix concrete mixers.*



***Trailers** for various services.*

MIG process is usually selected in such cases because of its higher welding speed and greater economy.

Aluminum sheet up to ¼ in. thick can be welded manually with complete penetration using a square butt design; heavier sections can be similarly joined if automatic welding is used. Two or more weld passes are employed for greater thicknesses. Manual welding of material more than ¼ in. thick should be done using single or double V-joints. Wherever possible, backup plates are recommended to control weld penetration; such plates also permit faster welding speeds.

Joint efficiencies up to 100% are regularly obtained in welding the 5000 series of alloys. The welding process and materials available make it possible to obtain welds that are consistently sound and crack-free, providing clean dry sheet or plate, suitable filler metal, proper joint design and correct welding procedure are employed. It is important to recognize that the weld metal is a casting and that filler metals are selected which will combine with the parent alloy to form strong, ductile weld deposits. Table 2 lists recommended filler metals and typical weld properties.

The only heat treatable aluminum alloy well adapted to fusion welding (6061) has been replaced in many welded structural applications by the 5000 group. Although 6061 has good strength in the heat treated T4 and T6 tempers, its strength in the annealed condition is relatively low. Full advantage of the alloy's properties can be taken only in structures that permit heat treatment after welding; unfortunately the ductility of the welded joint is reduced by the heat treatment.

Designing with 5000 series alloys

The newer 5000 series alloys offer this significant advantage: particularly strong in the as-welded condition, they also have good formability and corrosion resistance. Therefore, they offer an excellent combination of properties in highly stressed welded structures. These alloys also show improvements in mechanical properties at extremely low temperatures — a fact which has made them a preferred material for cryogenic applications.

Strength and design—A general rule for calculating the strength of welded joints is to use the properties of the annealed base plate as design criteria. However, joints are frequently stronger than the annealed parent metal. On sound welds with the beads intact, tensile fractures occur at the fusion line or in the annealed zone, adjacent to the weld bead, often at stresses greater than the strength of the annealed parent material.

Well designed aluminum structures weigh considerably less than similar steel structures. Aluminum weighs about 0.10 lb per cu in.; structural steel about 0.28, or nearly three times as much. Aluminum structures weigh from 35 to 70% of steel counterparts. This reduction in weight suggests a number of economic advantages to be gained through the use of aluminum. With the same safety factors applied to 5083 aluminum alloy and mild steel, the 5083 member will weigh about half as much as a steel member carrying an equivalent tensile load.

Stiffness and design—In many cases, the stiffness of a structural member is the governing factor in design. Stiffness, of course, is a function of the modulus of elasticity, which for aluminum alloys is about 10,300,000 psi as compared with 29,000,000 psi for structural steel, or a ratio of 1 to 2.8.

Under its own weight an aluminum beam will deflect the same amount as an identical steel beam,

TABLE 2—TYPICAL TRANSVERSE WELD PROPERTIES OF PLATE[a]

Base Alloy	Filler Alloy	Tensile Strength, 1000 psi	Yield Strength, 1000 psi	Elongation (in 2 in.), %
5052	5356 (5052)	28	14	15
5154	5154	33	17	15
5454	5554	35	16	15
5086	5356	37	18	17
5086	5183	39	17	21
5083	5356	40	21	16
5083	5183	43.5	21.8	16
5456	5556	46	23	15

[a]Welds made by the tungsten inert gas (TIG) and the metal inert gas (MIG) processes.

Two Welding Processes: How They Are Used

Although aluminum can be readily welded by other methods, the two welding methods recommended for the 5000 series of aluminum alloys, and almost universally used, are the tungsten-inert-gas (TIG) arc process and the metal-inert-gas (MIG) arc process.

In the TIG process a high frequency arc is established between a nonconsumable tungsten electrode and the aluminum parts to be welded. The arc melts the base metal, and a bare filler rod of suitable alloy is added to the molten pool.

In the MIG process a small diameter aluminum wire serves both as electrode and filler metal. This wire is fed automatically into the welding gun at high speed. MIG welding equipment is designed to initiate gas coverage and automatically feed the aluminum electrode into the weld area when a d.c. arc is struck. The high heat rate causes the welding pool to be formed after the arc is established, and welding is done by moving the welding gun rapidly along the line of the joint at a rate sufficient to build up a bead of the desired dimensions.

Atmospheres for welding — Both processes use inert gas (argon, helium or mixtures of the two) to protect the metal and eliminate use of a flux. Therefore the welds do not have to be cleaned. Small amounts of chlorine may be added to the gas through the contact tube in the MIG process to obtain superior welds.

The arc has a dual function, to supply heat for fusion welding and to break up the surface oxide on the aluminum. The inter-gas shield envelopes both the arc and weld pool, preventing oxidation from recurring while the metal is molten.

Welding position — Welding can be done in any position by either method. The gas shield formed is transparent so that the welder can see the fusion zone, which helps give neater and sounder welds. Although hand welding is most widely used, both processes are easily adapted to automatic equipment where the work is suitable and large volumes of welding are to be done.

Precleaning — Cleaning the surfaces to be welded just prior to welding is of major importance. Surfaces must be free of oil, grease and dirt. The oxide film should be removed by a suitable abrading process such as brushing with a clean stainless steel wire brush. Where more than one pass is required, the weld should also be brushed between passes.

since the aluminum beam weighs only about a third as much as the steel beam. Under the same applied load, the aluminum beam will deflect up to almost three times as much as the identical steel beam. Actual deflection depends upon the relationship of dead load to total load.

Equal stiffness, under the same conditions of loading, can be achieved with substantial weight reduction by selecting an aluminum beam having section properties increased by about 42%. For example, a 7-in. aluminum I-beam weighing 5.42 lb per ft has three times the moment of inertia of a 5-in. steel I-beam weighing 10 lb per ft. Therefore, equal stiffness is provided with little more than half the weight. Using an alloy such as 5083, the aluminum beam will provide equal or greater tensile strength than the steel beam. In addition, stresses due to bending in the aluminum beam will be less than half the stresses in the steel member.

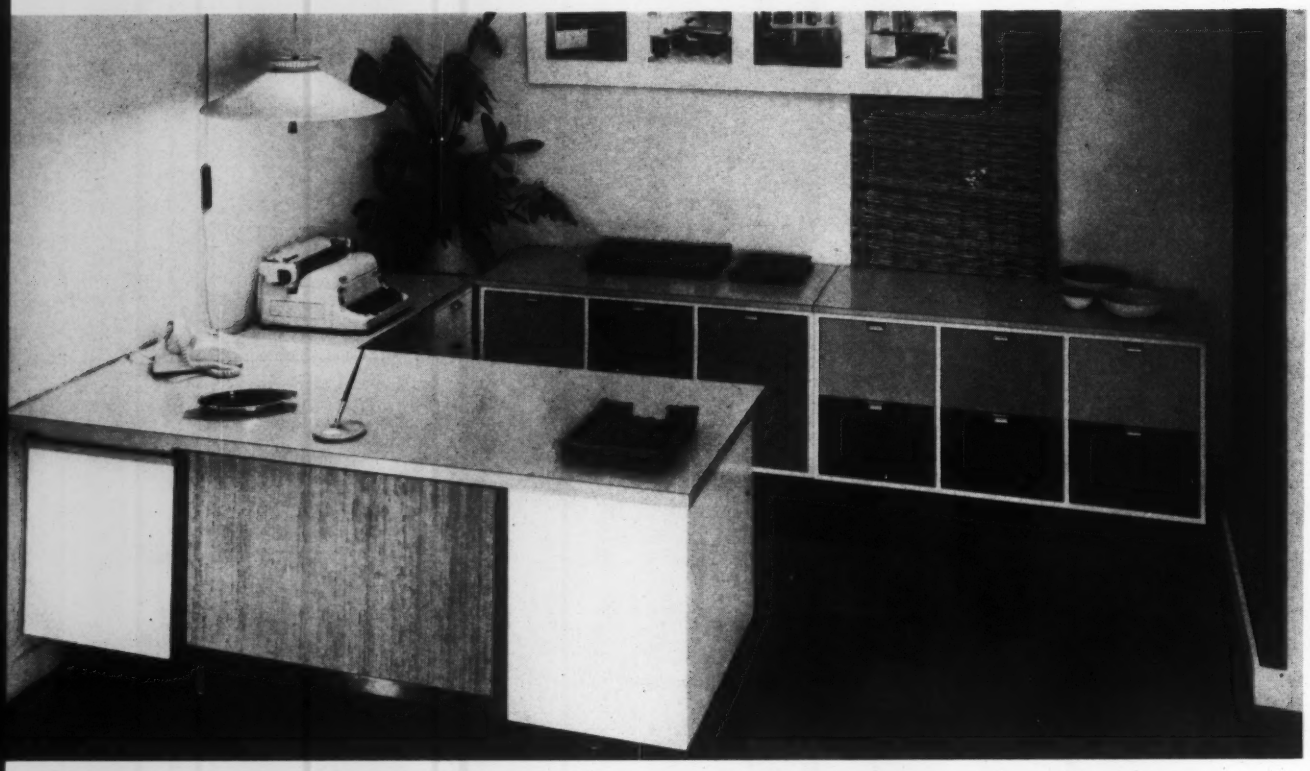
To take full advantage of the aluminum alloys, deflection criteria should be closely examined to make certain that the design is not needlessly penalized by arbitrary and unnecessarily severe deflection limitations. Reduction of deflection by the use of rigid framing and continuity should not be overlooked. The maximum deflection of a uniformly loaded, continuous beam of two equal spans is less than half that of a simple beam if unsupported length, loading and beam section properties are equal.

Compressive loading and design—The stability of compression elements is also affected by the modulus of elasticity. An aluminum column will carry only one-third the load of an identical steel column but will weigh one-third as much. By selecting a somewhat larger aluminum section, it is possible to support a load equal to that of a steel column with substantial weight reduction. For example, an 8 by 8-in. aluminum column will support about 1½ times the axial load that would be supported by a 8 by 5-in. wide flange steel column of the same length before becoming elastically unstable but the aluminum member will weigh 11 lb per ft compared with 20 lb per ft for the smaller steel section.

Two design advantages — In dealing with specific applications, it is important to note that too great an emphasis is frequently and needlessly placed on deflection characteristics. At the same time, it is worth noting that the lower modulus of elasticity of the aluminum alloys has a beneficial effect in absorbing impact loads and reducing stresses caused by inexact fit-up of members in a structure. Stresses induced by temperature changes in restrained members are also lower for aluminum than for steel, despite aluminum's greater coefficient of thermal expansion.

One further advantage that aluminum offers to the designer is that the extrusion process makes possible the economical production of special large-cross-section aluminum sections to provide highly efficient answers to specific design problems. The designer does not need to confine himself to utilization of standard or built-up shapes; by utilizing an extruded shape he frequently will find it possible to design a better structure and reduce fabrication cost at the same time.

For surfacing applications like these . . .



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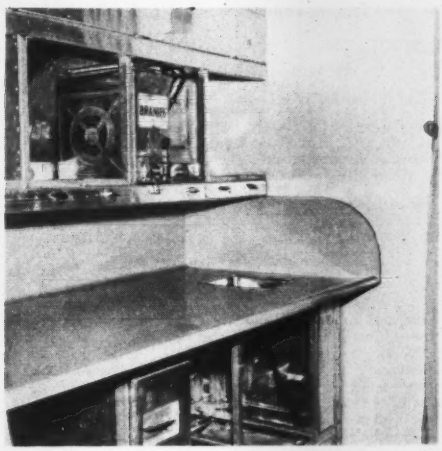


Airplane serving counter

Vending machines

Thermosetting Laminates

They combine durability with virtually unlimited decorative effects. Here is a summary of the types of laminates available, and the engineering information you need as a basis for specifications.

by Walter T. Davis,
Application Engineer, Formica Corp.

■ Take a strong, durable surfacing material, add virtually unlimited colorability and printability, and you have a decorative thermosetting laminate. Originally such laminates were used primarily for counter tops. Now, laminates which are both functional and decorative are used in a great many different products, such as appliances, vending machines and instrument housings.

Essentially, decorative thermosetting laminates consist of layers of fibrous sheet material impregnated with a thermosetting resin. Although each manufacturer of laminates has his own materials specifications, the protective overlay or top surfacing sheet is usually an alpha cellulose or rayon paper impregnated with a clear melamine resin. The next layers, containing the color or pattern, usually consist of pigmented alpha cellulose paper impregnated with melamine. The balance of the laminate is composed of kraft paper impregnated with phenolic resins.

The layers are consolidated under heat and pressure, producing a durable, decorative surfacing material. In use, decorative laminates are usually adhered to a core or backing material, such as wood or metal, to provide rigidity and impact resistance.

Since decorative possibilities are virtually unlimited, the discussion here is restricted to de-

SPECIFICATIONS FOR DECORATIVE THERMOSETTING LAMINATES—A SUMMARY

Property; NEMA Test Method	Type ➡	General Purpose & Cigarette-Proof	Postforming
Wear Resistance LP 2-2.01: Std specimens abraded with Tabor abraser. End point of wear test depends on type of surface: 1) printed surface—when an apprec portion of pattern is erased, 2) plain color surface other than black—when color layer is first cut through, 3) black surface—when a fibrous condn of surface is first observed. Results rptd as rate of wear per 100 cycles calc from: (weight loss at end point/wear value) × 100. Wear value is number of cycles at end point of test times a correction factor for sandpaper used		Rate of wear not exceed 0.08 gm/100 cycles. Wear value shall be: 400 cycles min for laminates designated as Class 1; 200 cycles min for laminates designated as Class 2	Same as General Purpose type
Resistance of Surface to Boiling Water LP 2-2.02: Water boiled in flat-bottom, round aluminum vessel; small amount of boiling water spilled on test specimen; vessel with remainder of water placed in puddle of water on specimen; allowed to stand for 20 min; vessel removed, specimen wiped dry and visually examined for damage		No blistering or other discernible surface disturbance	Same as General Purpose type
Resistance of Surface to High Temperature LP 2-2.03: Fisher Bath Wax (or equivalent) heated in flat-bottom, round aluminum vessel to 356 F; allowed to stand for 20 min on surface of specimen; surface visually examined for damage		**Satin-finish** laminates show no blistering or other discernible surface disturbance; **furniture** and **gloss finished** laminates show no blistering but surface finish may be slightly impaired	Same as General Purpose type
Resistance of Surface to Cigarette Burns LP 2-2.04: Resistance heater at 550-560 F positioned in jig 1½ in. from edge of specimen. Test timed until specimen fails by blistering, charring, permanent discoloration or crazing, or for 10 min; specimen allowed to cool to rm temp; test repeated with heater 1½ in. from point of first test; specimen cooled to rm temp; test repeated third time with heater 1½ in. from point of second test. Results rptd as avg time to failure for three tests		Surface not fail in less than 110 sec[a]	Surface not fail in less than 75 sec
Resistance of Surface to Stains LP 2-2.05: Surfaces wet-rubbed with pumice and washed. Each of 29 reagents[b] applied to surface and allowed to stand 16 hr at 75 F; specimens washed with water and a solvent; examined visually 1 hr after cleaning. Results reported as: 1) unaffected—no color chg; no apprec chg in surface texture, 2) superficial—stains easily removed by mild abrasives such as Lava soap or Bon Ami, or 3) considerable—stains not easily removed, or which result in etching		Laminate 1) unaffected by reagents 1-20[b]; 2) unaffected by reagents 21-29[b], except for stains classified as superficial	Laminate 1) unaffected by reagents 1 through 20[b]; 2) unaffected by reagents 21, 22, 23, 26, 28, 29, except for stains classified as superficial
Color Fastness LP 2-2.06: Samples exposed 48 hr in accel fading unit (test not used to determine weatherability). Observed chgs in surface texture and color rptd. **Slight change** is perceptible but insufficient to apprec alter orig color; **extreme change** is very obvious and results in marked chg in orig color		Not more than slight color chg, and no crazing	Same as General Purpose type
Boiling Water Resistance LP 2-2.07: Preweighed, measured and conditioned specimens immersed in boiling distilled water for 2 hr, removed and wiped dry; specimens immed weighed and measured. Results rptd as percent incr in wt and thk (to nearest 0.1%)		No crazing, chalking or delamination; avg of three test specimens, each having nominal 1/16-in. thk, shows a gain of not more than 6% in either wt or thk	No crazing, chalking cr delamination; avg of three test specimens, each having a nominal 0.051-in. thk, shows gain of not more than 12% in either wt or thk
Dimensional Stability LP 2-2.08: Premeasured specimens placed in oven at 158 F for 24 hr, removed and cooled to room temperature in desiccator for 1 hr. Specimens measured. Similar specimens placed in humidity chamber at 100 F and 100% RH for 7 days, removed, wiped dry and measured. Results rptd as 1) dimensions of specimens before and after each test, 2) percentage dimen chg, and 3) gross dimen chg, i.e., algebraic diff of avg dimen chgs in the low and high humidity tests		No crazing, chalking or delamination; 1/16-in. laminate shows gross dimen chg of not more than 0.5% with grain and 0.9% across grain	No crazing, chalking or delamination; 0.051-in. laminate shows a gross dimen chg of not more than 1.1% with grain and 1.4% across grain
Flexural Strength, Modulus of Elasticity, Deflection at Rupture LP 2-2.09: Test proc same as ASTM D790. Tests made flatwise in with-grain and across-grain directions and with face both in tension and compression. Span-depth ratio 16:1		1) Avg flex str not less than 18,000 psi in either with-grain or cross-grain direction with the decorative face in compression, and not less than 12,000 psi in either the with-grain or cross-grain direction with the decorative face in tension; 2) avg mod of elast not less than 800,000 psi under each loading condition specified; 3) min defl at rupture for 1/16-in. laminate 0.02 in. with face in tension, 0.03 in. with face in compr	Avg flex str not less than 15,000 psi in either with-grain or cross-grain direction with decorative face in compr, and not less than 12,000 psi in either with-grain or cross-grain direction with decorative face in tension
Appearance LP 2-2.10: Visual inspection standard. Results classified as: 1) type A defect—smudges, smears, fingerprints or streaks; 2) type B defect—any foreign particle 0.60 sq mm or larger, visible 7 ft from spot; 3) type C defect—group of three or more foreign particles, 0.30 sq mm each, which occur within 12-in. dia circle, visible 5 ft		None of listed defects evident	Same as General Purpose type
Formability LP 2-2.11: Bending characteristics of postforming grades of laminates at ¾ in. rad when heated to temp rec by laminator		Does not apply	Test specimens postform satisfactorily without blistering, cracking or delamination
Water Swell LP 2-2.12: Measured, weighed and preconditioned sample of hardboard-core type with ⅛ in. dia drilled hole in center immersed-in water at 122 F for 18 hr, removed, wiped, weighed and measured. Results reported as percentage incr in wt and thk		Does not apply	Does not apply

[a]For Cigarette-Proof type: surface shall not fail in less than 10 min.

[b]1) gasoline or naphtha, 2) water, 3) alcohol (ethyl, methyl and isopropyl), 4) amyl acetate, 5) acetone, 6) carbon tetrachloride, 7) moth spray (e.g., Larvex), 8) fly spray (e.g., Flit, 9) household soaps and washing powders, 10) soapless detergents (e.g., Dreft), 11) trisodiumphosphate (e.g., Oakite), 12) olive oil, 13) household ammonia solution (10% ammonia), 14) 10% citric acid solution, 15) coffee, 16) mustard (paste made of dry mustard), 17) sodium bisulfite, 18) wax crayon, 19) 66% urea (urine), 20) shoe polish (liquid or paste), 21) tea, 22) beet juice, 23) vinegar, 24) bluing, 25) dye (e.g., Tintex, Rit), 26) ink, washable, 27) iodine solution (1% iodine in alcohol), 28) 2% mercurochrome solution (aqueous), 29) 5% phenol solution in water (Lysol).

sign properties and fabricating characteristics.

Four standard types

Although a number of proprietary grades of decorative thermosetting laminates are available, specifications for four standard grades have been established by NEMA (National Electrical Manufacturers' Assn.) The accompanying table lists property requirements for the four types

	Hardboard Core
	Min wear value: 250 cycles
	Same as General Purpose type
	Same as General Purpose type
	Surface not fail in less than 110 sec
	Same as General Purpose type
	Same as General Purpose type
	Does not apply
	Does not apply
	Does not apply
	Same as General Purpose type
	Does not apply
	Avg of three test specimens shows gain of not more than 25% in either wt or thk; laminate shows no chalking or delamination

as measured by the 12 standard NEMA test methods used to determine quality of the laminates. The four standard types are as follows:

General purpose type is designed for use where requirements call for good appearance, durability, resistance to stain, and resistance to heat from ordinary sources. Backs of sheets can be sanded to permit bonding with adhesives to a suitable core or base material. (This is also true of cigarette-proof and postforming types of laminates.)

General purpose type laminates are available in thicknesses from 1/16 through 1/4 in. with tolerances ranging from ±0.005 in. for the thinnest sheet to ±0.012 in. for the thickest. Sheet sizes range in widths from 24 to 48 in. and in length from 60 to 120 in.

Cigarette-proof type is similar to general purpose type, but has a heat conductive layer to dissipate heat from a concentrated source, such as a lighted cigarette. Laminates are available in the same thicknesses, tolerances and sizes as general purpose type.

Postforming type is similar to the general purpose laminate, but can be formed by the purchaser under controlled temperature and pressure in accordance with the laminator's recommendations.

Laminates are available in a thickness of 0.051 in. with a tolerance of ±0.004 in. Sheet sizes are the same as for general purpose type.

Hardboard-core type has a surface similar to that of the general purpose type, but is laminated to a hardboard core, which is generally self-supporting. The hardboard core consists of lignocellulosic wood fibers consolidated under heat and pressure and bonded either with the natural lignin in the wood alone, or with the aid of thermosetting resin additions to improve the bond.

Laminates are available in nominal thicknesses ranging from 5/32 through 5/16 in. Sheet sizes range in width from 24 to 48 in. and are 96 in. long.

Standard finishes

Although a variety of textured finishes can be produced, laminates are generally available in one or more of four finishes:

1. *Plate finish* is that formed by the surface of the metal plate on the press. No additional treatment is required after the laminate leaves the press.

2. *Gloss finish* is produced by buffing plate finish surfaces with polishing compounds. Light reflectance is increased, giving a high gloss. Buffing also tends to remove any imperfections which might appear on a plate finish.

3. *Satin finish* is produced by slightly abrading plate finishes with a pumice mixture. Light reflectance is reduced, providing a dull or satin effect.

4. *Furniture finish* is produced by lightly abrading or reworking plate finishes to reduce light reflectance to about half that of a gloss finish. Resulting finish resembles that of an oil stained, hand rubbed wood.

Postforming

Supplied as a flat sheet, postforming grades of decorative laminates can be formed to simple curvatures prior to bonding to core or backing materials. Postforming to compound curvatures is still in the development stage, but appears promising. The box on p 100 describes the types of heat sources used and the general postforming technique.

There are definite limitations to the formability of postforming decorative laminates. These limitations depend on the type of laminate, its thickness, and type of decorative surface. Though specific limitations differ somewhat from one laminator to another, the radii limitations in the table (next page) are recommended by Formica Corp. and may be considered typical. Remember that the decorative surface may be either on the outside of the bend or on the inside of the bend. Values given for O.R. are minimum radii for outside decorative surfaces in tension (not including laminate thickness, which must be added). Values given for I.R. are minimum radii for inside decorative surfaces in compression (no correction for thickness necessary). Data are given for 0.051-in. thick material.

Material	O.R., in.	I.R., in.
Black	½	¼
Solid Colors	1	⅜
Patterns	¾	¼

Backing materials

Decorative thermosetting laminates require a core or substrate to provide both resistance to impact and restraint on dimensional change stresses induced by the hygroscopic nature of the laminates. Laminates can be applied to most porous or nonporous surfaces, but the most common backing materials are wood or metal.

Wood—Both plywood and wood particle boards are commonly used. Plywood cores should be grade AD or better with cross-grained face veneers, such as Philippine mahogany, poplar, bass, gum or birch. Where high humidity or excessive moisture is expected, exterior grade plywoood should be used. Rotary-cut fir plywood can be used, but care should be taken to prevent show-through or "telegraphing" of the plywood grain through the laminate surface. This is particularly a problem when using water-base adhesives requiring heat and pressure for curing.

A number of wood particle boards are available for use as core materials. A satisfactory board should have a modulus of rupture of 3000 psi, and screw holding power of 250 psi on the face and 200 psi on the edge. (For further information on particle boards see "Versatile Low Cost Wood Composition Boards," M/DE, Aug '57, p. 107.)

Metal — Steel, aluminum and other nonporous materials may be used as backings for decorative laminates. Most commonly used metal is 16 to 20-gage cold rolled steel. In all cases where metals are to be used as core materials, surfaces must be smooth and uniform, i.e., free from spot welds, ridges or other defects.

Selecting an adhesive

A variety of adhesives are available for bonding laminates to core materials. Proper selection must be based on the type of core material and the type of end service for which the laminate is intended.

Bonding to wood—Outlined below are the adhesives recommended for bonding laminates to wood, and the general design requirements each type meets. Recommendations for specific formulations can be obtained from laminators or adhesive formulators.

Four types of resin-based adhesives are used:

1. Resin emulsions (polyvinyl acetates) are satisfactory only where the assembly is to be exposed to normal indoor conditions, i.e., where water, high humidity, or materials likely to promote mold or fungus growths are not likely to reach the glue line for a long time.

2. Caseins, though they have slightly better water resistance than resin emulsions, are only satisfactory for normal indoor conditions as outlined above. Caseins are essentially cold setting and cure time cannot be reduced substantially by application of heat.

3. Urea formaldehyde adhesives provide good bond strengths and water resistance slightly better than that of caseins. In general, they should not be used continuously above 150 F or intermittently above 210 F. Ureas may be cured at room temperature; such cures are usually equivalent to those required for caseins. Curing time of ureas can be substantially reduced by use of heat, such as that provided during hot pressing.

4. Resorcinol and phenol-resorcinol combinations are among the finest commercially available adhesives. Essentially waterproof, they provide high bond strength, good heat resistance and excellent resistance to acids and alkalis. They cost more than caseins or ureas and require heat curing.

Also used are many types of flexible cements—liquid and paste adhesives made from natural, reclaimed and synthetic rubbers, sometimes in combination with resins. They are available as solvent, emulsion and water-base types. Results obtained are dependent on individual formulation used. One of the most satisfactory flexible cements for quality bonds is the neoprene-base solvent type with 18 to 35% solids content.

Bonding to metal—For bonding laminates to metal, solvent-type neoprene-base adhesives should usually be used. Both brush and spray techniques are satisfactory.

How to Postform

Postforming grade laminates are first heated, then formed either in a die with fixed radii, or by a rolling action described under *increment heating* below.

Four major types of heating are used. These are:

1. *Increment heating* — Material is placed on a thermostatically controlled, radiused heater and held in position 30 sec. Sheet is then rolled gradually and with a constant motion through 100 deg of radius. Postformed part is left for 2 min on increment heater to set in formed position.

2. *Infrared radiant heating*—Quick heating method. Sheet is brought up to 313 F in 40 to 50 sec, placed in forming apparatus and formed immediately. Forming action should be complete within 10 sec after material has been removed from heating position.

3. *Infrared lamp oven heating*—Used to heat areas too large for methods *1* and *2* above. Oven temperature is 500 F, allowing laminate to be quickly heated to 313 F postforming temperature. Postforming should be complete within 10 sec after material has been removed from heating position.

4. *Contact-heated platen heaters*—Sheet is held against a heated surface, usually aluminum alloy, for a given length of time. After material has been heated to optimum forming temperature (313 F) it is placed in forming apparatus and formed immediately. Forming action should be complete within 10 sec after material has been removed from heating position.

Reference

Laminated Thermosetting Decorative Sheets, NEMA Standards Publication No. LP 2-1957.

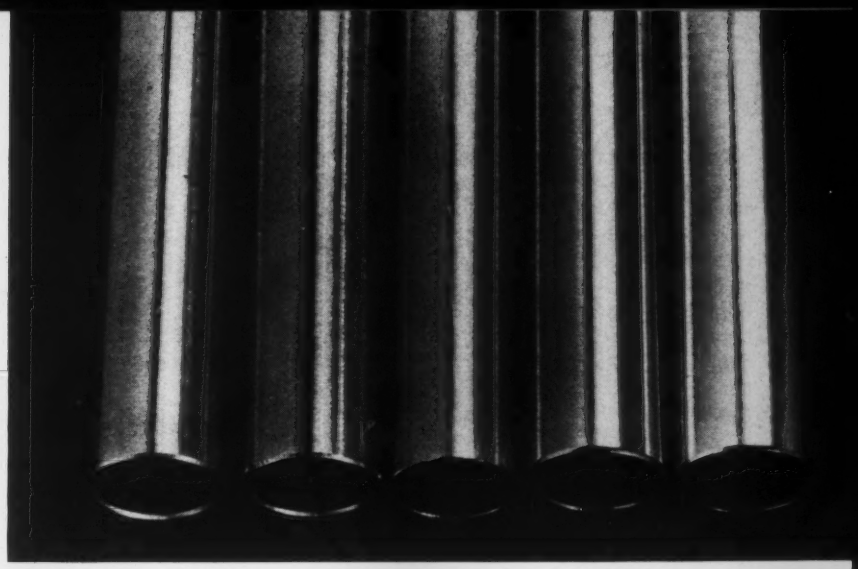
Choosing Surface Finishes for Small Tubing

Selection of the proper finish is an important step in designing tubular products. Here are the finishes you can specify . . . and where to use them.

by James H. Black, *Metallurgical Dept., Superior Tube Co.*

■ A wide range of surface finishes have been developed for small tubing (under 0.5 in.) to meet all appearance and operating requirements. In most applications only the type of finish required need be specified. However, where operating requirements are severe it may also be necessary to specify surface roughness limits in microinches (see box).

The various surface finishes available to the designer are described below and in the accompanying table. These finishes can be produced on all stainless steel and titanium tubing, and on several grades of nickel alloy tubing. Of these finishes, the pickled and the bright finishes are probably the most commonly used.



Typical finishes *obtainable on small tubing are (left to right): bright, No. 320 grit polished, pickled, tumbled, and bright pickled. Differences among them are obscured somewhat by loss of detail in photoengraving process.*

When to use a pickled finish

A pickled finish has a fine, satin appearance which makes it more desirable for some applications than a bright finish. It can be produced on all types of stainless steel in sizes down to 0.1875 in. o.d. The finish is applied on both the interior and exterior of the tubing, and can be produced on coiled tubing and on straight tubing in lengths up to 39 ft. Surface roughness averages less than 125 microin.

A pickled surface is sometimes more desirable than a smooth surface. This is particularly true in heat exchanger tubing where a slightly rough, pickled surface provides more metal area for the transfer of heat. The roughened surface also produces small continuous bubbles in the surrounding fluid instead of the more undesirable large bubbles that are sometimes produced by smooth surfaces.

Pickled tubing can also be advantageous in electronic applications, such as cathodes where high emissivity is needed. The rough surface created by pickling in effect doubles the surface area and thereby doubles the emissivity of the part.

When to use a bright, smooth finish

In general, a bright smooth finish is the best all-around finish for most tubing applications. As indicated below, a number of bright smooth finishes are available, the so-called "bright finish" being the most popular and widely used.

Types available

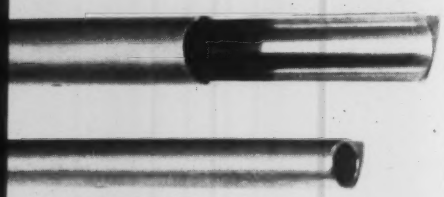
Bright finish—A bright finish is produced by pickling the tubing and then drawing it through tungsten carbide or diamond dies. This combined treatment produces a smooth, bright outer finish. No premium charge is made for this type of finish, and it can be produced on straight tubing up to 39 ft long. Surface roughness of the finish usually averages less than 63 microin.

Polished finish—Centerless polishing is used to produce tubing with low exterior surface roughness and to remove minute surface imperfections. The finish is available on all standard tubing materials in straight lengths up to 30 ft and with outside diameters from 0.032 to 1.5 in. The finish cannot be produced on extremely light wall tubing.

Tumbled finish—This is the smoothest finish that can be produced on the exterior of tubing. In addition to its smoothing action, tumbling removes all burrs and produces a mirror-like finish. A tumbled finish is limited to tubing less than 3.5 in. long. The degree to which the finish is produced on tubing interiors is determined by the size of the tumbling media and the tube i.d.

Sanitary finish—This finish is produced by drawing tubing over a stationary and highly polished tungsten carbide mandrel plug. The finish is bright, extremely smooth and uniform, and is easily cleaned and sterilized. It is sometimes referred to as a burnished i.d. or dairy finish. It is restricted to tubing with a maximum length of 24 ft and a maximum wall thickness of 0.065 in.

Bright pickled — This finish (offered exclusively by Superior Tube Co.) was developed to meet the need for a bright finish equivalent in reflectivity to an electropolished finish but capable of being produced on the inside of tubing as well as the outside. The finish is produced chemically and is available on stainless steel, monel and nickel tubing having a minimum i.d. of 0.25 in. in lengths up to 4 ft. A bright pickled finish can be produced on tubing that has already been given a commercial bright or pickled finish.



***Difference in appearance** of inner and outer surfaces is apparent in this sectioned tube. Exterior is "pickled", interior "sanitary."*

Why they are used

A bright smooth finish can be used to:

Improve sanitation—The smoother the surface, the less likely it is to pick up dirt, small particles and microbes. A smooth surface is also easier to clean and sterilize because the peaks and valleys in the surface profile are not exaggerated. For these reasons a bright smooth sanitary finish is particularly useful for tubing used in medical, surgical and dental devices, and in food and drug processing equipment.

Reduce fatigue cracking — A smooth surface helps prevent fatigue cracking caused by vibration, repeated bending and other forces. For example, specifying high external and internal smoothness on stainless steel hydraulic aircraft tubing helps considerably to prevent fatigue cracking caused by vibration and high surges of pressure.

Ease passage of fluids—It is axiomatic that a smoother surface offers lower resistance to the flow of liquids and gases. The difference is particularly important in instrument applications and hydraulic lines. In one special application—a heat exchanger used to cool blood during heart operations—tubing with an especially smooth i.d. is specified to prevent rupture of blood corpuscles as they flow through the tubing.

Increase corrosion resistance—A smooth surface has better corrosion resistance than a rough surface because it does not contain minute pockets which can hold the corroding medium. For example, specifying a very smooth internal finish for the tubing used in mercury columns prevents the mercury from amalgamating in the tubing. (The extremely smooth surface also minimizes the surface tension of the mercury.)

How to specify them

Assuming that a smooth finish is desirable, the engineer or designer should determine what degree of smoothness is required and whether the finish is needed on the tube o.d., the i.d., or both. For example, if a smooth finish is required only on the tube o.d. and if a maximum surface roughness of 63 microin. can be tolerated, then a commercial bright finish should be adequate. However, if

FINISHES THAT CAN BE PRODUCED ON SMALL TUBING

Finish ↓	Surface to Which Applied	Tubing Material	Available Tube Sizes			
			O.D., in.	I.D., in.	Wall Thk, in.	Max Length, ft
Pickled	Exterior	Stainless steel	Any	0.1875 min	Any	39
	Interior	Nickel alloys, titanium				
Bright	Exterior	Stainless steel, nickel alloys, titanium	Any	—	Any	39
Polished	Exterior	All standard tubing alloys	0.025-0.375	—	Any	30
			0.375-1.5	—	0.02 max	30
Tumbled	Exterior	All standard tubing alloys	0.75 max	0.375 min	0.015 min	3.5 in. max
	Interior		0.75 and over	0.375 min	0.015 min	3.5 in. max
Sanitary	Interior	Stainless steel, nickel alloys, titanium	—	Any	Any	24 max
Bright Pickled	Exterior	Stainless steel	0.625 max	0.25 min	Any	4 max
	Interior	Monel, nickel				

The Importance of Surface Roughness

In many noncritical applications, finishes for small tubing can be specified by type (polished, bright, etc.), rather than by the allowable surface roughness required. However, in critical applications, such as instruments, aircraft lines and precision parts, some limits must be placed on surface roughness in order to meet operating requirements.

It is difficult to recommend surface roughness limits that would apply for each application. However, the table below shows the range of surface roughness obtainable by various polishing and machining operations. In addition, the following recommendations can be given to designers and users who may wish to check and measure surface roughness in their own plants. These specifications are followed at Superior Tube Co. and are largely based on American Standards Assn. B46.1-1955 (sponsored by SAE and ASME) and Military Standard MIL-STD-10A.

1. All measurements should be made in the longitudinal direction, unless specified in the circumferential direction. Circumferential measurements can be made on tubing ½ in. o.d. and larger.

2. Mechanical tracing should be used at all times at a speed of ⅛ ips. The trace should be not less than 0.6 in. long.

3. Outside measurements should be made at least 1.0 in. from the tube end.

4. Surface roughness should be measured as the average of four readings taken 90 deg apart.

5. Tube samples should be at least 4 in. long.

6. Internal measurements on tubing with an i.d. of 0.5 in. and larger should be made at least 1.0 in. from the tube end.

Measuring *surface roughness limits in microin. Such limits are becoming an increasingly important specification for critical uses.*

SURFACE ROUGHNESS PRODUCED BY POLISHING AND MACHINING

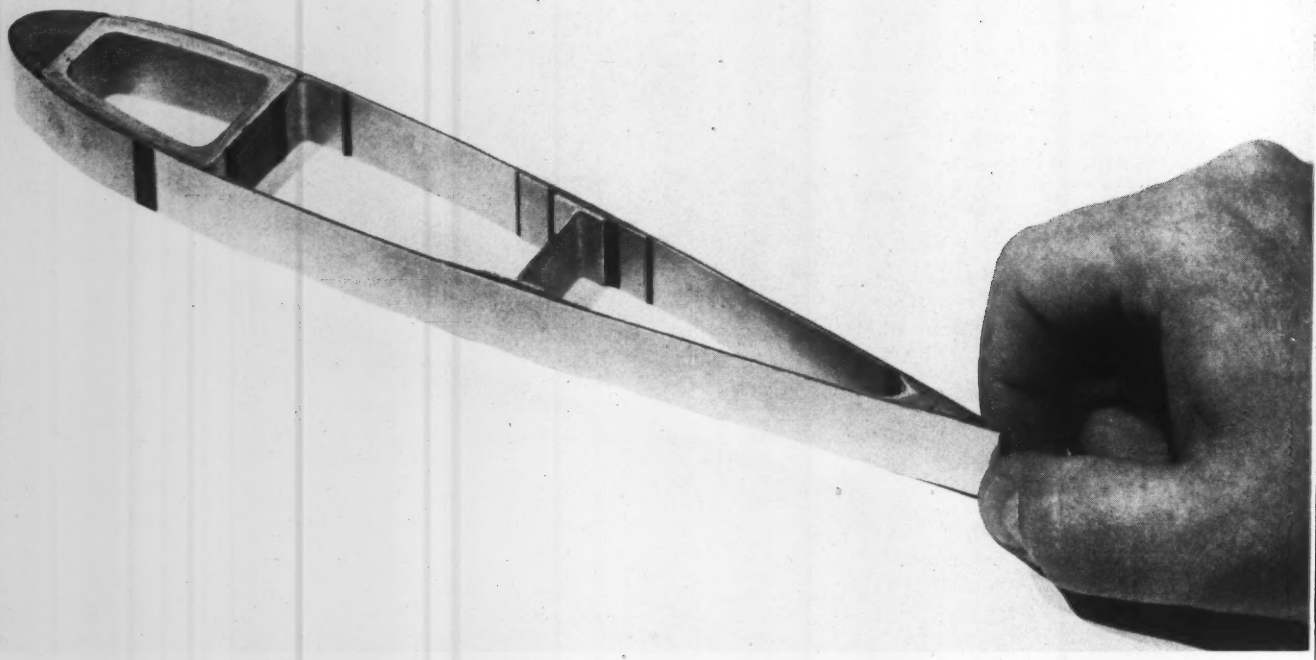
Required Surface Roughness, microin.	Corresponding Grit Number Required in Polishing	Corresponding Machine Operation Required
4-16	500	Very fine, high quality finish produced by fine cylindrical grinding, emery buffing, honing, lapping, or other special finishing operations
10-32	320	32 microin. is a high grade machine finish produced with close control on lathes, shapers, milling machines, etc.
15-63	240	63 microin. is a good machine finish produced under controlled production procedures using relatively high speeds, fine feeds, and light cuts with well-sharpened cutters
85 max	180	—
125 max	120	Medium commercial machine finish using relatively high speeds and fine feeds, and light cuts with well-sharpened cutters
250 max	60	Coarse production finish produced by very coarse grind, disk grind or rough file; and by rapid feeds in turning, milling, shaping and boring operations

Measurements of tubing with an i.d. between 0.25 and 0.499 in. should be made at least 1.0 in. from the end.

7. Internal measurements on tubing with an i.d. between 0.125 and 0.249 in. should be made by sectioning the tube in a longitudinal direction to a length of at least 1.5 in. Measurements should be made at least 0.5 in. from the tube end and do not necessarily have to be made 90 deg apart.

the o.d. surface must be smoother than 63 microin., a polished surface should be specified.

If the tubing is very short (less than 3½ in. long), then tumbling may prove to be the most economical method of producing the desired finish. If an extra-smooth finish is required on the i.d. only, a sanitary finish produced by plug drawing may be required. Naturally, the application requirements should be discussed with the tubing supplier before final selection is made.



Helicopter rotor blades *fabricated from three metals by adhesive bonding have better life and vibration resistance than riveted blades.*

Three Major Types of

High Strength Adhesives

Approach Bond Strength of Welding, Fastening

by E. F. Hess, *Product Manager, Minnesota Mining & Mfg. Co.*

Vaporizer reservoir *is adhesive bonded to eliminate distortion and finishing operations characteristic of old design which used seam welding.*

■ The performance of structural adhesive bonds now places this bonding method on a par with fastening and welding techniques. The light metals, in particular, can now be joined more strongly with adhesives. In thin sheets the bond strength often exceeds the strength of the metal itself.

Another consideration—elevated temperatures—no longer need mean a blanket dismissal of adhesives. Organic adhesives can be used at reasonably high temperatures (up to 450 F) if protected

PROPERTIES OF SOME STRUCTURAL ADHESIVE TYPES

Type →	Modified Epoxies		Phenolic-Elastomeric[a]	Phenolic-Thermoplastic[b]
	RT Cured	Heat Cured		
CURING PROCEDURE				
Temperature, F	70–90	320–500	300–400	250–350
Pressure, psi	Contact	Contact	25–200	50–200
Time, min	1–7 days	2–60	2–60	30–120
MECHANICAL PROPERTIES				
Shear Strength, psi				
−65 F	350–2500	1300–5000	3500–4500	2000–3000
68 F	2500–4200	3000–5000	2000–6000	2500–5000
180 F	180–900	2600–5000	1500–2800	800–4000
250 F	—	800–3600	500–2500	100–1800
300 F	—	450–3200	400–2220	100–1200
350 F	—	200–1200	300–1700	100–500
Creep Strength[c]				
Room Temperature	Excellent	Excellent	Good	Excellent
Elev Temperature	Poo	Good[d]	Good	Good[d]
Peel Strength	Poor	Poor	Excellent	Fair-good
Flexibility	Poor	Poor	Excellent	Fair-good
CHEMICAL RESISTANCE				
Water	Fair	Excellent	Excellent	Excellent
100% Relative Humidity	Fair	Excellent	Excellent	Excellent
Salt Spray	Poor	Excellent	Excellent	Excellent
Oils	Excellent	Excellent	Excellent	Excellent
Glycols	Good	Good	Excellent	Excellent
Fuels	Exce lent	Excellent	Excellent	Excellent

[a]Based on nitrile phenolics.
[b]Based on vinyl phenolics.
[c]Creep strength and dead-load strength.
[d]To limiting temperatures.

from oxidation.

At the same time adhesive bonding has certain inherent advantages from the standpoints of both cost and design. Perhaps most important is the fact that the continuous bonds achieved can distribute stress loads uniformly over the joined area. This often permits the use of lighter gage metals and is particularly advantageous where the tear strength of a thin sheet would limit the strength of other joining and fastening methods.

Tied in with the stress distribution advantage is the resistance to vibrational fatigue made possible by the flexibility of the bonds. In addition, adhesive bonding can provide sound structural members with smooth contours.

Corrosion is minimized by adhesive bonding. The bond acts as a barrier to bimetallic corrosion. It also prevents entrapment of moisture between surfaces and acts as an effective seal.

Three broad categories of organic structural adhesives are in wide use today: modified epoxies, phenolic-thermoplastic compounds and phenolic-elastomeric compounds. Ranges of properties for such bonds are given in the table on this page.

The thermoplastic or elastomeric components of these compounds serve to plasticize the thermoset, to toughen it and to raise its impact strength. Nevertheless, the physical properties remain closer to those of the thermoset than to the other components used. Because various components may be used, there are many adhesive types within each category. The epoxies are generally classified as room temperature-curing (two-part) or heat-curing (one-part) types while the phenolics are classified according to the thermoplastic or elastomeric component.

1. Modified epoxies

These adhesives are excellent for metal-to-metal bonding and for honeycomb sandwich construction. Advantages include exceptionally high shear strength, excellent self-filleting properties (unequaled by other available honeycomb sandwich panel adhesives), high rigidity, and excellent wetting of metal and glass surfaces. No volatile by-products are given off during the curing cycle, thus making epoxy adhesives particularly useful for bonding impervious surfaces.

Epoxy resin adhesives will produce from 2000 to 6000 psi overlap shear strength depending on the particular adhesive used. Heat curing epoxies have higher strengths than the room temperature curing formulas and maintain their strength over a wider temperature range.

Typical Applications

At the present time the aircraft industry is the largest consumer of high strength adhesives. In addition to their extended use for honeycomb panels, elastomeric-thermosetting films are used to bond the leading and trailing edges of aluminum aircraft wings and helicopter rotor blades, and have proved their ability to reduce vibration damage. Other aircraft uses for structural adhesives include such components as bulkheads, floors, rudder parts, aileron members, wing panels and integral wing fuel tanks; also such guided missile parts as stiffeners and fins.

Some commercial uses for adhesive bonding include: rotor end plates for air motors, vaporizer reservoir for beautician equipment, end connectors for flexible steel tubing, metal clips for plastics cabinets, stiffeners for large thin-gage metal surfaces, torque converter housings for automatic bus transmissions and corner joints of metal framework. Some of these are illustrated in this article.

Chemical resistance depends on the formulation, but in general epoxies will resist most solvents, mild acids and mild alkalis. Although most epoxy-based adhesives will lose a portion of their strength after long submersion in water (particularly at elevated temperatures), water resistance is considered generally good.

The chief disadvantages of epoxy adhesives are low peel strength, lack of flexibility, and inability to withstand high impact. They are quite expensive but designers often find that their performance is worth the cost.

Two main types—Epoxies are available as two-part, room temperature, chemically curing types, and as one-part heat curing types. Two-part epoxy adhesives require the addition of a chemical activator at the time of application, which in turn requires weighing and mixing operations. The working life of the two-part type ranges from 15 min to 4 hr. Some may reach ultimate strength within 15 hr, but usually 4 to 6 days setting time is needed. One-part epoxy adhesives have a latent catalyst added to the adhesive formulation at time of manufacture. Unlike two-part epoxies, the working life of the one-part type is unlimited.

Two-part types are usually cured with amines and lose strength rapidly at 150 F. Post-curing for 30 to 60 min at 200 F improves strength properties and raises the maximum temperature performance level to 180 F.

Cure times for the one-part type at 320-350 F will range from 60 to 90 min. At 500 F cure time drops to about 1½ min, but care must be taken to prevent overcuring. Usually, exposing the bond to 350 F for extended periods does not appreciably affect the properties of the adhesive line. In most cases, contact pressure or relatively low pressures are needed during the cure cycle.

Although the majority of epoxies are 100% non-volatile formulations containing no solvents or reaction by-products, some low viscosity epoxy resin adhesives containing a solvent have been used in special applications.

2. Thermoplastic-phenolic adhesives

Vinyl formal-phenolic — These one-part solvent type adhesives have good shear and peel strengths, and good heat resistance. Depending on the metal bonded, tensile strengths range from 1000 to 4000 psi. Resistance to creep is considered good, although the adhesive softens somewhat at elevated temperatures. The fatigue properties are good—typical of thermosetting resins. Peel strength is superior to that obtained with epoxies.

The adhesives are usually supplied as a resin solution or in film form. In the film form, the adhesive is coated on both sides of a reinforcing fabric. In some cases the liquid phenolic resin must be mixed with the vinyl formal powder prior to use.

Prior to bonding, liquid vinyl phenolic adhesives must be air dried, then force dried at 150-180 F for periods up to 30 min, to minimize the amount of volatile material given off during cure. In some cases predrying also improves strength properties.

After drying, the curing procedure is the same as with the film adhesive. Both are cured under a pressure of 50 to 150 psi and at temperatures from 240 to 325 F. The optimum film thickness will vary from 2 to 6 mils depending on the type of mating surface and the stress distribution qualities required.

Vinyl butyral-phenolic — The most popular use is in sandwich panel construction for bonding of metals and high pressure laminate facings to resin-treated paper honeycomb cores. Bonds have high shear strength at room temperature which drops off as the thermoplastic limit of the vinyl butyral is approached. Compared with the vinyl formal-phenolic adhesives, they have lower shear strength and are not quite as tough. They are supplied as solvent solutions or in film form, and are cured by the same methods as the vinyl formal types.

3. Elastomeric-phenolic adhesives

Neoprene-phenolic—These have good adhesion to most metals and plastics and usually offer good flexibility, vibration absorption and peel strength.

They are particularly suited to

Other Factors in Picking an Adhesive

Many factors—ranging from assembly line setups to end service conditions—must be considered when selecting an adhesive. In choosing the chemical type of adhesive, the materials being bonded and the required bond properties generally receive first consideration. Conversely, in choosing the adhesive form, production requirements are a primary influence. Preparation of the adhesive; the time, temperature and pressure requirements; labor and equipment needed—all must be weighed.

Structural adhesives are available in the form of solvent solutions, 100% nonvolatile liquids and films. Solvent solutions are standard and of long standing. The nonvolatile liquids are limited to the epoxies. Film adhesives are gaining increased acceptance and should be considered first because of their design and cost saving advantages. Such advantages include: uniform bond thickness, confinement to the immediate bonding area, clean bonding operations and simple application procedures. Because film adhesives do not contain solvents, waste and shrinkage are avoided, and solvent hazards and drying problems are eliminated.

But, whether choosing a form or a particular chemical type of adhesive, there are so many variables involved that only by full consultation with the adhesives formulator can proper selection be made. There is no all-purpose adhesive for all types of design and service. All adhesives are formulated to produce a fair balance of properties with emphasis on certain features.

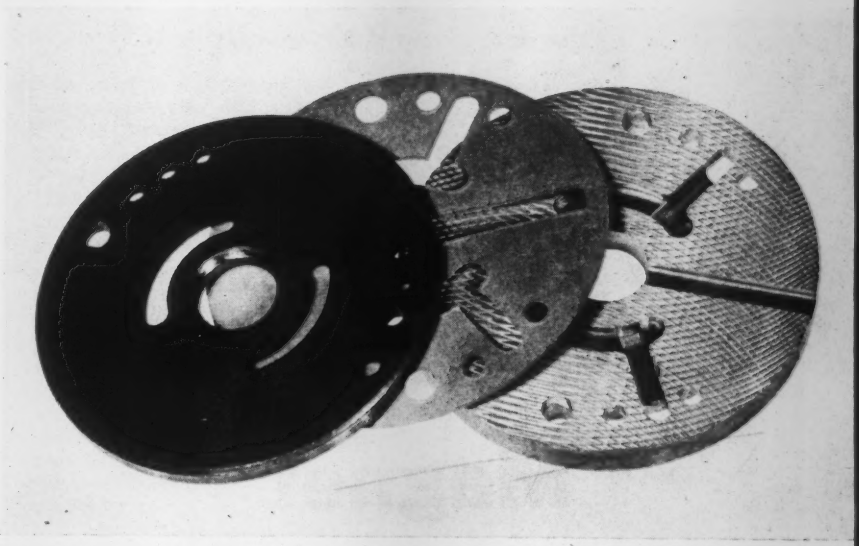
the joining of thin metal sheets to themselves or to supporting structures. They may be used in honeycomb construction if a special effort is made to physically form a fillet between the honeycomb and skin, but the adhesives do not self-fillet. The bonds have a tendency to creep at elevated temperatures when subjected to dead loads greater than two-thirds the shear strength.

The adhesives are usually moderately priced. Most are solvent types but special two-part chemical-curing types are sometimes used to obtain specific properties. Heat-curing types in dry film form are also available and are compounded to have higher strength and heat resistance. They usually perform better if the metal is first primed with a liquid adhesive.

In general, bonds produced with dry film neoprene adhesives have excellent resistance to fatigue and peel (heat cured adhesives have sufficient elasticity to allow stress equalization) and are effective over a wide temperature range. Strength at 180 F is generally half that at room temperature.

Nitrile-phenolic — These adhesives are the latest development in high-strength elastomeric types and are rapidly replacing the vinyl and neoprene-phenolic types. This class of adhesives has a broader range of properties, superior flexibility, better salt-spray resistance and a higher service temperature range.

Nitrile-phenolic adhesives have tensile strengths ranging from 4000 to 8000 psi. Good impact strength and fatigue resistance properties, as well as resistance to plastic flow and creep, are typical. Some formulations are suitable at —80 F but shear strength and impact resistance are considerably reduced. Generally, these adhesives can be used in continuous service at 250 F. Some films will withstand moderate stress at temperatures as high as 500 or 600 F for short periods. At 400 F, shear values of 800 psi have been achieved when evaluated by MIL-A-8331 specification methods.



Air motor end plates *consist of powdered iron disk bonded with film adhesive to a cast aluminum plate. Bonding method permits use of wear resistant, lightweight metals to replace machined bronze plates.*

Nitrile-phenolic adhesives are available in liquid and dry film forms. Some of the dry films have fabric interliners. Although a satisfactory cure can be obtained by curing at 320 F for 60 to 90 min, superior strengths at higher service temperatures are obtained if the adhesives are cured at 350 F or above. The required pressure during cure is 50-150 psi.

Composite film adhesives

A new series of heat curing supported composite film adhesives has been developed for honeycomb sandwich construction. They consist of a nitrile phenolic film on one surface and a self-filleting epoxy film on the other. The elastomeric adhesive bonds to the facing and the self-filleting adhesive bonds to the core of the honeycomb sandwich panel. This new concept permits the formulation of adhesive films that provide the highest combination of peel strength and beam shear strength at service temperatures ranging from –70 F to 250 F.

These films have produced aluminum honeycomb sandwich panels with a beam shear flexure strength of 1580, 1530 and 1385 psi at –67 F, 80 F and 180 F respectively. Panels had peel strengths of 18, 24 and 21 in. lb per in. at these temperatures.

In addition to their strength advantages, supported composite film adhesives eliminate the need for sandwich core priming. This advantage increases production of bonded sandwich components, reduces fabrication costs, reduces weight of the finished panel, saves factory and storage space, and reduces equipment costs and manpower requirements.

The future for adhesives

A further increase in adhesive strength properties is possible but this increase will have no effect on uses at ordinary temperatures, i.e., room to 180 F. Development work is continuing to extend the temperature range, particularly today's upper limit of about 450 F. Inorganic adhesives now have fair strength at 800 F and this limit will be extended.

Other trends include development of adhesives resistant to the newer lubricants, fluids and fuels, and adhesive compounds requiring lower bonding pressures and shorter heat cures. At present adhesives required to have high strength properties at elevated temperatures must be cured at these temperatures.

Here is a comprehensive survey of

Permanent Magnet Materials

- *Magnet steels*
- *Alnicos*
- *Other magnetic alloys*
- *Ceramics*
- *Fine particle magnets*

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

■ Permanent magnet materials can be used in a wide range of applications where a self-contained source of potential energy is needed. Their use ranges from simple door latches having a high holding force, on up to complex motor stators having a strong, inherent magnetic field. A great number of permanent magnet materials have been developed to meet the needs of such varied applications. The purpose of this article is to describe the various metal and ceramic materials that are available today.

In the past, the magnet steels (described first below) were the only permanent magnet materials available to the designer. Although they are still used to a limited extent today, they have been replaced in many applications by the newer permanent magnet alloys and ceramics which possess superior magnetic properties.

Magnet steels

are generally low in cost and are available in a wide variety of shapes and sizes. Although suitable for some applications, they are not used where high magnetic strength, small size or light weight is required.

At one time the magnet steels were the only permanent magnet materials available to the designer. Although they are still used to a limited extent today, they have been replaced in many applications by the newer permanent magnet alloys and ceramics which possess superior magnetic properties.

Depending on the composition, the maximum energy product $(B_dH_d)_{max}$ of magnet steels ranges from 0.18 to 1.03 x 10^6 gauss-oersted. Many magnet steels, especially the cobalt steels, can be cast directly into the shape required. In addition, practically all of the steels can be either 1) rolled or forged when hot or 2) cold worked and machined.

Carbon steels

Carbon steels (sometimes called carbon-manganese steels) were the first group of materials developed especially for permanent magnets. The steels are ordinary high carbon steels containing from 0.7 to 1.5% carbon. The permanent magnet properties of the steels derive from contained carbides. Quenching from 1470 F produces a hard material with fairly high retentivity and coercivity. With some exceptions the magnetic properties of magnetic steels (as well as the magnetic alloys) parallel mechanical hardness.

Carbon steel magnets have fairly high residual induction, but because of their low coercive force they must be made quite long. A further disadvantage is that their magnetic properties deteriorate on exposure to mechanical vibration, shock, temperature variations, and stray electrical fields. These disadvantages may, in some cases, outweigh the cost advantage of the materials.

Tungsten steels

The presence of tungsten in permanent magnet steels tends to increase both coercive force and residual induction. Tungsten steels containing 5 to 6% tungsten and 0.5 to 1% carbon have been found best for magnetic uses. The maximum energy product for a typical tungsten steel in this composition range is 0.33 x 10^6 gauss-oersted, as compared to 0.18 to 0.20 x 10^6 for the carbon steels. Despite their relatively poor magnetic properties, the tungsten steels are still used where size is unimportant.

Some tungsten steels contain enough chromium to make them air hardening. However, most tungsten steels, as well as the 2% chromium steel and the carbon-

manganese steels, are water hardening. In general, tungsten steel magnets are forged, then machined to shape.

Chromium steels

Chromium magnet steels owe their development to the shortage of tungsten during World War I. As shown in the table (see next page), the maximum energy product values of the chromium steels are not as high as those of the tungsten steels. However, magnetic differences between the two materials are not appreciable and the chromium steels have the advantage of being lower in cost.

Compared to carbon steels, the tungsten and chromium steels are more stable after temperature changes and mechanical shock but, nevertheless, they still show some magnetic variations upon aging. Because of their high remanence the tungsten and chromium steels are useful for magnets requiring a small cross-sectional area.

Cobalt steels

The cobalt steels were largely developed in Japan where investigators found that additions of about 35% cobalt greatly increase the coercive force of steels containing 5 to 9% chromium and small amounts of tungsten. In general, an increase in cobalt content is accompanied by an approximately linear increase in coercive force and an increase in residual induction and maximum energy product. Higher coercive forces can be obtained with the cobalt steels than with the carbon, tungsten or chromium steels.

A wide range of magnetic properties can be obtained with the cobalt alloys within suitable composition limits. As shown in the table, manufacturers have established a number of standard alloys, the principal ones containing 3, 9, 17 and 36% cobalt. All of these alloys are martensitic and contain iron-carbon precipitates throughout the crystal lattices as a result of quenching from about 1475 to 1750 F.

Before the Alnico alloys were introduced, the 36% cobalt alloy was the best permanent magnet material known, the maximum energy product being 1.0 x 10^6 gauss-oersted. The alloy is still used today in a limited number of applications; however, it is relatively expensive for the amount of energy that it produces.

How Permanent Magnets Behave

In order to design a permanent magnet that will perform a given function, the designer must have a basic understanding of how ferromagnetic materials behave. The following description, supplied by Indiana Steel Products Co., explains how the magnetic properties of materials are obtained, and explains their significance.

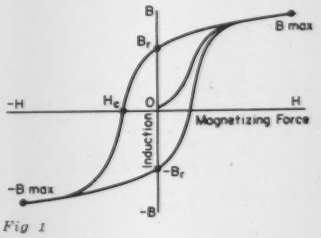


Fig 1

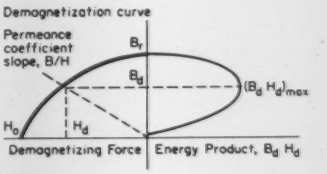


Fig 2

Understanding the hysteresis loop

Fig 1 shows how the induction in a magnetic material changes as the magnetizing force is varied. When demagnitized material is subjected to a gradually increasing magnetizing force up to H_{max}, the induction in the material increases from zero to B_{max}. If the magnetizing force is then gradually reduced to zero, the induction decreases from B_{max} to B_r on the vertical axis. This B_r value is known as the residual induction.

If the magnetizing force is reversed in direction and increased in value, the induction in the material is further reduced, and it becomes zero when the demagnetizing force reaches a value of H_c, known as the coercive force. A further increase of this negative force causes the induction to reverse direction, becoming $-B_{max}$ at $-H_{max}$. If the magnetizing force is reversed from this point to H_{max}, the change in induction is along curve $-B_{max}$, $-B_r$, B_{max}. This cycle gives the complete hysteresis loop.

Such a curve applies to all magnetic materials, the difference in materials being largely a matter of the values. Materials having a low coercive force are low-energy materials, and those having a high coercive force are high-energy materials. These are commonly known as soft and hard materials, respectively, but the terms low-energy and high-energy are more representative of the characteristics of magnetic materials.

Obtaining the maximum energy product

The section of the hysteresis loop from B_r to H_c is of major interest to designers of permanent magnets. This is known as the demagnetization curve and is shown in Fig 2. At the right of this curve is the conventional energy product curve, which is the product of B and H as taken from the demagnitization curve and plotted against B. The product of B_d and H_d at any point on the demagnitization curve indicates the useful energy produced per unit of volume. In the cgs system where B_d is in gauss and H_d is in oersteds, $B_dH_d/8\pi$ is equal to energy product in ergs per cu cm. The external energy is zero at both B_r and H_c, and reaches a peak value at a point known as the peak energy product, $(B_dH_d)_{max}$. This point represents the maximum external energy that can be produced by a unit volume of a given material. It is a criterion for comparing different permanent magnet materials. Furthermore, in the case of fixed air gap applications the design which causes the magnet to work at the maximum energy point will require the least volume of magnet material.

Iron-nickel-aluminum

permanent magnet materials (the Alnicos) have excellent magnetic properties, including very high maximum energy products. They are well suited where high force and small size are needed; however, because of their hardness and brittleness they are difficult to fabricate.

Alnico permanent magnet materials are dispersion hardened alloys consisting basically of iron, nickel and aluminum, with varying additions of cobalt, copper or titanium. Like many other magnetic alloys (such as Cunife, Cunico and Bismanol) the Alnicos derive their name from the elements they contain: Al-Ni-Co. As shown in the table, a wide variety of Alnico materials are available, the principal ones being Alnico I, II, III, IV, V, VI and XII. All of these alloys are available only as sand castings, with the exception of Alnico II, IV, V and VI which can be produced by powder metallurgy. (Alloys similar to the Alnicos are marketed in Europe as Alcomax, Ticonal and Hycomax alloys.)

Cast Alnico magnets are quite difficult to machine and can only be finished by grinding. Consequently, the casting mold must correspond to the final shape of the magnet. All holes must be incorporated in the casting. Knurled inserts can also be incorporated. These inserts can be tapped or machined after the final heat treatment. Since Alnico has a low hot-tear strength and high shrinkage (about 11/32 in. per ft), the section around an insert must be provided with adequate material to prevent cracking.

The as-cast tolerances of sand-cast Alnico magnets are:

Dimension Size	Tolerance
Up to 1 in.	±0.015 in.
1 to 4 in.	±0.032 in.
4 to 6 in.	±0.045 in.

For greatest economy, Alnico magnets should have tolerances as large as possible so as to avoid the need for grinding. Thin sections, abrupt section changes, and sharp internal corners should be avoided.

Sintered Alnico magnets are fine grained and are stronger than the cast Alnicos. However, their magnetic properties are about 10% below those of cast Alnicos. The nature of the powder metallurgy process permits closer dimensional control; however, the process is generally limited to magnets weighing less than 0.05 lb.

Sintered magnets must be designed to permit pressing in one

PROPERTIES OF

Material	Composition (or Materials Supplier)	Magnetic Properties			
		Resid Flux Density B_r, gauss	Coer Force H_c, oe	Max Energy Prod, gauss-oe x 10^{-6} a	B_d at $(B_dH_d)_{max}$, gauss
MAGNET STEELS					
0.65% Carbon	0.65 C, 0.85 Mn, bal Fe	10,000	42	0.18	6,500
1% Carbon	1 C, 0.5 Mn, bal Fe	9,000	51	0.20	5,900
5% Tungsten	5 W, 0.7 C, bal Fe	10,500	70	0.33	7,000
6% Tungsten	6 W, 0.7 C, 0.5 Mn, 0.5 Cr, bal Fe	9,500	74	0.33	6,500
1% Chromium	0.9 Cr, 0.6 C, 0.45 Mn, bal Fe	9,500	52	0.23	6,500
2% Chromium	2.15 Cr, 0.9 C, bal Fe	9,300	60	0.26	6,300
3½% Chromium	3.5 Cr, 1 C, 0.5 Mn, bal Fe	9,500	66	0.29	6,500
6% Chromium	6 Cr, 1.1 C, 0.4 Mn, bal Fe	9,500	74	0.30	6,200
3% Cobalt	3 Co, 9 Cr, 1.5 Mo, 1.05 C, bal Fe	7,200	130	0.35	4,280
6% Cobalt	6 Co, 9 Cr, 1.5 Mo, 1.05 C, bal Fe	7,500	145	0.44	4,700
9% Cobalt	9 Co, 0.9 C, 1.25 W, 5 Cr, bal Fe	7,800	122	0.41	5,100
17% Cobalt	17 Co, 0.7 C, 8.25 W, 2.5 Cr, bal Fe	9,500	150	0.65	6,000
36% Cobalt	36 Co, 0.8 C, 3.75 W, 5.75 Cr, bal Fe	10,000	240	1.0	6,300
40% Cobalt	40 Co, 0.7 C, 5 W, 4.25 Cr, bal Fe	10,000	242	1.03	6,500
IRON-NICKEL-ALUMINUM					
Alnico I	12 Al, 20 Ni, 5 Co, bal Fe	7,000	440	1.4	4,500
Alnico II (cast)	10 Al, 17 Ni, 12.5 Co, 6 Cu, bal Fe	7,200	560	1.6	4,700
Alnico II (sintered)	10 Al, 17 Ni, 12.5 Co, 6 Cu, bal Fe	6,900	520	1.45	4,300
Alnico III	12 Al, 25 Ni, bal Fe	6,900	470	1.35	4,300
Alnico IV (cast)	12 Al, 28 Ni, 5 Co, bal Fe	5,500	700	1.3	3,000
Alnico IV (sintered)	12 Al, 28 Ni, 5 Co, bal Fe	5,200	700	1.2	3,000
Alnico V (cast)	8 Al, 14 Ni, 24 Co, 3 Cu, bal Fe	12,500	600	5.25	10,200
Alnico V (sintered)	8 Al, 14 Ni, 24 Co, 3 Cu, bal Fe	10,500	600	3.5	7,800
Alnico VI (cast)	8 Al, 15 Ni, 24 Co, 3 Cu, 1 Ti, bal Fe	10,100	750	3.8	7,000
Alnico VI (sintered)	8 Al, 15 Ni, 24 Co, 3 Cu, 1 Ti, bal Fe	8,800	800	2.75	5,500
Alnico XII	6 Al, 18 Ni, 3.5 Co, 8 Ti, bal Fe	5,500	950	1.6	3,000
OTHER MAGNETIC ALLOYS					
Cunife I	60 Cu, 20 Ni, 20 Fe	5,400	500	1.3	4,000
Cunife II	50 Cu, 20 Ni, 2.5 Co, 27.5 Fe	7,300	260	0.78	4,700
Cunico I	50 Cu, 21 Ni, 29 Co	3,400	700	0.8	2,000
Cunico II	35 Cu, 24 Ni, 41 Co	5,300	450	0.99	3,400
Remalloy, Comol	12 Co, 17 Mo, bal Fe	10,000	230	1.1	6,900
Indalloy	12 Co, 17 Mo	9,000	240	0.9	6,000
Vicalloy I	9.5 Va, 38.5 Fe, 52 Co	9,000	300	1.0	5,500
Vicalloy II	13 Va, 35 Fe, 52 Co	10,000	450	3.0	8,200
Silmanal	86.75 Ag, 8.8 Mn, 4.45 Al	590	6,300	0.083	292
Platinum	77.8 Pt, 22.2 Fe	5,830	1,570	3.07	3,400
	76.7 Pt, 23.3 Co	4,500	2,700	4.00	2,600
Platinax II	Co,Pt	6,400	4,800	9.2	3,400
Nipermag	12 Al, 30 Ni, 0.4 Ti, bal Fe	5,600	660	1.34	3,400
Bismanol	20.8 Mn, 79.2 Bi	4,800	3,650	5.3	2,640
New KS	3.7 Al, 17.7 Ni, 27.2 Co, 6.7 Ti, bal Fe	7,150	785	2.03	4,300

Notes on next page.

PERMANENT MAGNET MATERIALS

Physical Properties					Mechanical Properties		
Density, lb/cu in.	Elec Res, ohm-cm	Ability to Res. Demag Fields	Min Temp Perm Affect Material, F	Curie Temp, F[b]	Ten Str, psi	Trans Mod of Rupture, psi	Hardness, R_c
0.283	18 x 10^{-6}	—	—	—	300,000	—	60-65
0.282	20 x 10^{-6}	—	—	—	300,000	—	60-65
0.292	28 x 10^{-6}	—	—	—	300,000	—	60-65
0.294	30 x 10^{-6}	—	—	—	300,000	—	60-65
0.282	23 x 10^{-6}	—	—	—	300,000	—	60-65
0.282	28 x 10^{-6}	—	—	—	300,000	—	60-65
0.281	29 x 10^{-6}	Poor	250	—	300,000	—	60-65
0.281	34 x 10^{-6}	—	—	—	300,000	—	60-65
0.278	—	—	—	—	—	—	—
0.282	—	—	—	—	—	—	—
0.286	30 x 10^{-6}	—	—	—	300,000	—	60-65
0.302	23 x 10^{-6}	Fair	300	—	300,000	—	—
0.296	25 x 10^{-6}	Fair	300	—	300,000	—	—
0.296	25 x 10^{-6}	—	—	—	300,000	—	60-65
0.249	75 x 10^{-6}	Good	1,000	—	4,100	13,900	45
0.256	65 x 10^{-6}	Good	1,000	—	3,000	7,700	45
0.243	68 x 10^{-6}	Good	900	—	65,000	70,000	—
0.249	60 x 10^{-6}	Good	900	—	12,000	22,500	45
0.253	75 x 10^{-6}	Exc	1,100	—	9,100	24,000	45
0.250	68 x 10^{-6}	Exc	1,100	—	60,000	85,000	—
0.265	47 x 10^{-6}	Good	1,000	—	5,450	10,500	50
0.241	50 x 10^{-6}	Good	1,000	—	50,000	—	—
0.268	50 x 10^{-6}	Exc	1,000	—	23,000	45,000	56
0.241	—	Exc	1,000	—	—	—	—
0.264	62 x 10^{-6}	Exc+	900	—	—	—	58
0.311	18 x 10^{-6}	Good	900	—	100,000	—	200 Bhn
0.311	18 x 10^{-6}	—	—	—	100,000	—	200 Bhn
0.300	24 x 10^{-6}	Exc	—	—	85,000	—	200 Bhn
0.300	—	—	—	—	100,000	—	200 Bhn
0.295	45 x 10^{-6}	—	—	—	—	—	60
0.288	48 x 10^{-6}	Fair	—	—	125,000	—	—
0.296	60 x 10^{-6}	—	—	—	—	—	60
0.293	60 x 10^{-6}	—	—	—	—	—	60
0.325	26 x 10^{-6}	Exc	—	—	110,000	—	230 Bhn
0.559	—	—	—	—	103,000	—	26
0.559	42 x 10^{-6}	—	—	—	—	—	26
0.548	—	—	—	—	—	—	200-315 Bhn
0.249	66 x 10^{-6}	—	—	—	10,500	23,000	45
0.25	—	—	—	—	—	—	—
0.268	55 x 10^{-6}	—	—	—	—	—	—

continued on next page

direction. Thus, the contour and holes of the magnet must be parallel to the direction of pressing. Sections should be uniform in the direction of pressing since the powder does not flow.

The tolerances of sintered Alnico magnets are:

Dimension Size	Tolerance
Up to 0.125 in.	±0.005 in.
0.125 to 0.625 in.	±0.010 in.
0.625 to 1.25 in.	±0.015 in.

Alnico I

Compared to the other Alnicos, Alnico I is inexpensive and can be used in a wider range of applications. It was the first of the Alnicos to contain cobalt and it differs from the original Alnico III only in that 5% of the nickel is replaced with cobalt. As shown in the table, the properties of Alnico I and III are not too different. However, Alnico I is preferred for larger magnets and, because of its cobalt content, has better response to heat treatment.

Alnico II

The development of Alnico II stemmed from the discovery that coercive force could be improved with no loss in residual induction by markedly increasing cobalt content and adding copper. Alnico II costs slightly more than Alnicos I, III and IV. However, it produces greater energy per unit volume than all other Alnicos except Alnico V and VI which are anisotropic. (An alloy is anisotropic when its magnetic properties are better in one direction than in another.)

Alnico III

Alnico III was the first Alnico alloy to be developed and, despite its name, does not contain any cobalt. The alloy has the lowest density of the Alnicos and is generally used for short, low cost magnets.

Alnico IV

The composition of Alnico IV is similar to that of Alnico I except that nickel content is increased from 20 to 28%. Alnico IV is comparatively inexpensive and is useful in applications requiring a high coercive force where some sacrifice in residual induction can be tolerated. Except for Alnico XII, it has the highest coercive force of any of the isotropic (exhibiting magnetic properties in all directions) Alnicos. It is especially well suited for applications where magnet length is limited.

Alnico V

Alnico V is an anistropic alloy and has one of the highest energy products of the commercial alloys (5.5 x 10^6 gauss-oersted). Maximum economy is obtained when the alloy is used at or near its maximum energy product. It performs very well in components

having a fixed air gap. Induction of the alloy falls off rapidly when a demagnetizing force of about 500 oersted is exceeded.

Alnico VI

Alnico VI differs in composition from Alnico V only in that 1% titanium is added to produce higher coercive force, increased resistance to demagnetization, and higher mechanical strength. However, the alloy has a lower value of residual induction than Alnico V, and its maximum energy product is lower (3.65×10^6 gauss-oersted). Like Alnico IV, the alloy is used where magnet length is limited.

Alnico XII

This alloy contains comparatively high percentages of cobalt and titanium and is noted for its high coercive force. The alloy is extremely brittle and is quite difficult to fabricate.

Other magnetic alloys

are available with a wide range of properties to satisfy specialized needs. Some types are designed to be ductile and easily formed; others are designed for high coercive force, low cost and light weight.

Cunife

Cunife is a 60 copper-20 nickel-20% iron alloy which is especially designed to be malleable, ductile and easily formed after heat treatment. The alloy can be readily fabricated by swaging, drawing, rolling, punching or machining. It is anisotropic and is roughly comparable in magnetic properties to Alnico III. The alloy generally exhibits its best magnetic properties in wire sizes below 0.2 in. dia. It can be produced in diameters up to 1 in. and in strips up to ⅛ in. thick, but the larger cross sections lower magnetic properties. Rectangular magnets should not be more than 0.625 in. wide and should not be less than 0.04 in. thick.

Cunico

In general, the properties of Cunico (50 copper-21 nickel-29% cobalt) are similar to those of Cunife. However, Cunico is isotropic and can be produced in a greater variety of shapes and sizes than Cunife. The alloy is largely used in wire, rod, or strip form (it can also be cast) and is useful in applications where a machinable magnet with high coercive force is needed.

Remalloy (Comol)

The magnetic properties of Remalloy (17 molybdenum-12% cobalt) are similar to those of 36% cobalt magnet steel, but the alloy is less expensive, easier to machine, and much more stable with time and temperature. The material can be made in the form of sand castings as well as hot rolled bars and forgings. It is commonly used for telephone receivers and is relatively inexpensive for a given flux density.

Indalloy

The composition of Indalloy is exactly the same as that of Remalloy and Comol. However, the material is processed by powder metallurgy methods similar to those used with the sintered Alnicos. The alloy is not ductile and can only be finished by grinding. It is especially useful for the low cost production of small, close-tolerance magnets in large quantities. Weight is generally limited to 0.006 to 2 oz, and cross-sectional area to 0.01 to 2 sq in.

Vicalloy

Vicalloy is a 52 cobalt-12% vanadium alloy which can be readily cold worked. Its magnetic properties are quite similar to those

PROPERTIES OF

Material	Composition (or Materials Supplier)	Magnetic Properties: Resid Flux Density B_r, gauss	Coer Force H_c, oe	Max Energy Prod, gauss-oe x 10^{-6} [a]	B_d at $(B_dH_d)_{max}$, gauss
CERAMICS					
Arnox Va	Arnold Engrng. Co.	3,850	1,500	3.5	—
Arnox III	Arnold Engrng. Co.	2,000	1,100	0.4	—
Cromag	Henry L. Crowley & Co., Inc.	2,000	1,550	0.8	950
Ceramagnet A	Stackpole Carbon Co.	2,200	1,700	1.01	1,150
F-300	D. M. Steward Mfg. Co.	2,000	1,600	0.84	—
Ferbalite 5802	Lignes Telegraphiques et Telephoniques	2,600	1,700	1.4	1,500
Ferbalite 5803	Lignes Telegraphiques et Telephoniques	1,800	1,500	0.6	900
Ferbalite 5804	Lignes Telegraphiques et Telephoniques	2,100	1,600	0.9	1,100
Ferrolite 5201	Lignes Telegraphiques et Telephoniques	2,400	1,800	1.5	1,400
Ferrolite 5202	Lignes Telegraphiques et Telephoniques	2,500	1,250	1.3	1,300
Ferrolite 5203	Lignes Telegraphiques et Telephoniques	2,600	1,000	1.2	1,850
Ferrimag I	Crucible Steel Co. of America	2,100	1,650	1.0	1,130
Ferrimag V	Crucible Steel Co. of America	3,900	2,000	3.5	—
Indox I	Indiana Steel Products Co.	2,100	1,700	1.01	1,055
Indox V	Indiana Steel Products Co.	3,800	2,000	3.5	1,920
Indox VI	Indiana Steel Products Co.	3,200	2,550	2.4	1,600
Magnadur 1	Mullard Ltd.	2,000	1,750	0.95	950
Magnadur 2	Mullard Ltd.	3,600	1,400	2.5	2,200
Magnadur 3	Mullard Ltd.	3,000	1,900	2.25	1,600
FINE PARTICLE [c]					
ESD Iron (isotropic)	Fe	5,400	600	1.3	—
ESD Iron (anisotropic)	Fe	7,000	670	2.15	—
ESD Iron-Cobalt (isotropic)	Fe, Co	5,620	820	1.6	—
ESD Iron-Cobalt (anisotropic)	Fe, Co	7,900	1,000	3.5	—
Flexible Vinyl [d]	Flexible vinyl plus magnetic particles	1,400	1,150	0.402	—

[a] $(B_d\ H_d)_{max}$.
[b] Roughly the temperature at which magnets begin to lose their magnetism.
[c] Properties vary widely depending on packing fraction. Values quoted are for 0.4 packing fraction.

PERMANENT MAGNET MATERIALS (continued)

Physical Properties					Mechanical Properties		
Density, lb/cu in.	Elec Res, ohm-cm	Ability to Res. Demag Fields	Min Temp Perm Affect Material, F	Curie Temp, F[b]	Ten Str, psi	Trans Mod of Rupture, psi	Hardness, R_c
0.181	10^4	—	—	860	—	—	—
0.170	10^6	—	—	—	—	—	—
—	10^6	—	—	752	—	—	—
—	—	—	—	—	—	—	—
—	10^6	—	—	842	—	—	—
—	10^6	—	—	—	—	—	—
—	10^6	—	—	—	—	—	—
—	10^6	—	—	—	—	—	—
—	100	—	—	—	—	—	—
—	5×10^5	—	—	—	—	—	—
—	100	—	—	—	—	—	—
0.170	10^6	—	—	—	—	—	—
—	—	—	—	—	—	—	—
0.17	10^6	—	—	860	—	—	—
0.181	—	—	—	860	—	—	—
0.162	—	Exc	—	860	—	—	—
—	10^6	—	—	—	—	—	—
—	10^6	—	—	—	—	—	—
—	10^6	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
0.134	—	—	—	—	—	—	—

[d]This newly announced magnetic material consists of a specially compounded flexible vinyl impregnated with magnetic particles. It is isotropic and is available in an unlimited number of shapes and sizes, including long continuous lengths. At present it is largely used for door seals, but it can be used for many of the same applications as conventional magnetic materials.

of 36% cobalt steel. It has proved especially useful in hysteresis motors and compasses, and for the recording of speech in wire and tape recorders. The alloy can be machined, punched, tapped or drilled, and can be rolled into thin sheets or drawn into fine wire. Because of its high cobalt content the alloy is relatively expensive.

Silmanal

As its name implies, Silmanal is a silver-base (86 silver-9 manganese-5% aluminum) alloy. Although it has a low maximum energy product and residual induction, it has very high intrinsic coercive force (about 6000 oersted). The alloy requires very high magnetizing forces and is extremely difficult to demagnetize, thus making it particularly useful where adverse magnetic fields are encountered. Long pieces are especially difficult to magnetize, though the alloy can be produced in wire or rod form. The alloy is usually used in short lengths with high cross-sectional area. The material is relatively expensive but is very ductile and easily machined.

Platinum alloys

Alloys containing about 77% platinum and 23% iron or cobalt exhibit a very high coercive force and maximum energy product (3 to 4 x 10^6 gauss-oersted). However, despite their favorable magnetic properties, high cost limits them to specialized uses.

A newly announced proprietary cobalt-platinum alloy (Platinax II) is claimed to be one of the most powerful permanent magnet materials yet developed. The alloy is isotropic and has a maximum energy product of 9.2 x 10^6 gauss-oersted. It is particularly useful in manufacturing magnets of complicated shape and small size (such as magnets for electric watches). It is fairly ductile and can be machined, rolled or drawn without difficulty.

Bismanol

Little information has been published on the properties of the Bismanol (manganese - bismuth) permanent magnet alloy. This alloy was discovered in France and was largely developed at the U.S. Naval Ordnance Laboratory. Very high maximum energy products (5.3 x 10^6 gauss-oersted) have been reported for the material, but its use is said to be limited because of oxidation problems and loss of magnetic properties at low temperatures.

Ceramic

permanent magnet materials are lightweight and nonconductive, and have high resistance to demagnetization. Some types have very high coercive force; on an equal weight basis their magnetic energy equals that of some magnetic alloys.

The development of ceramics for permanent magnets is one of the most important advances in permanent magnets since the development of the Alnico materials. Ceramic permanent magnet materials are sometimes called ferrites or hard ferrites. However, strictly speaking they are not ferrites, although they are closely related to these materials. The ceramics are derived from the natural mineral magnetoplumbite ($PbFe_{12}O_{19}$). Barium is usually substituted for the lead to improve magnetic properties.

Magnetic properties—The magnetic properties of ceramic permanent magnets can vary over a wide range, depending on composition. Compared to the Alnicos, the ceramic materials have a very high coercive force. Certain ceramics, in fact, have the highest coercive force of any commercial

magnetic material. Because of their high coercive force, such ceramics can be designed with short magnet length, but because of their low flux density, they usually require high cross-sectional area.

The maximum energy product of ceramic permanent magnets varies over a wide range—from 0.4 to 3.5 x 10^6 gauss-oersted. On an equivalent weight basis, the maximum energy product of some ceramics is comparable to that of Alnico V.

All ceramic materials have high resistance to demagnetization by vibration and shock. Some materials are so resistant that after the application of a demagnetizing field sufficient to reduce the flux to zero, the magnet will recover and exhibit its original magnetic properties. The resistance of ceramic magnets to demagnetization is particularly important in cycle dynamos and in applications where the magnet works in a fairly large air gap.

Other advantages—A significant advantage of ceramic permanent magnets is their nonconductivity. This property permits ceramic magnets to be used in applications where ordinary metal magnets would create an undesirable current path or short circuit. In addition, eddy current losses and associated heating are low when the ceramics are exposed to high frequency alternating fields. Thus, ceramic magnets can be successfully used to provide a polarizing field in inductors and transformers.

Two other important advantages of ceramic magnet materials are their light weight and low cost. Ceramic magnets are about 35% lower in density than metal magnets with equivalent maximum energy products. This can be an important factor in lightweight military applications. As for cost, ceramic permanent magnets have replaced metal magnets in such things as magnetic oil filters, toys and door latches with appreciable cost savings.

Mechanical properties and fabrication—The mechanical properties of ceramic magnets depend largely on the way they are manufactured. The magnets are made from a mixture of finely divided oxides and a binder which is compressed to shape and baked at high temperatures. During sintering some ceramics can shrink to as little as ⅞ of their original size in all directions. The mechanical properties also depend on composition of the binder, degree of compression, and the kind and amount of heat treatment.

The fabrication characteristics of ceramic magnets also vary widely. Some types are quite hard and brittle and are extremely difficult to drill and machine, although they can be finished to some extent by grinding. On the other hand, some types are relatively soft and can be machined readily by drilling, milling or tapping. These soft types are made by bonding the ceramic particles in plastic and, because of their plastic content, have weaker magnetic properties than hard ceramic magnets.

Fine particle materials

have recently been placed in production. They are easily formed into a variety of shapes, and their magnetic properties are generally superior to those of the magnet steels.

Permanent magnets made from soft ferromagnetic metal powders are now being produced in the United States, England and France. In England the permanent magnets (called Gecalloy) are made by preparing very fine powders of iron or iron alloys (micropowders), then pressing the powders to the desired shape under very high pressure. The magnets have a maximum energy product equal to, and in some cases better than, those of the best isotropic magnet steels. Because of their softness these magnets can be molded into very accurate shapes and can be machined without difficulty.

Recent announcement has been made in the United States of the limited commercial availability of permanent magnets made of ultrafine, elongated-single-domain (ESD) particles of iron or iron-cobalt. The particles are prepared by electrodepositing iron or iron-cobalt into mercury. The resulting particles are then concentrated by a magnetic field into a thick slurry and the mercury removed by vacuum distillation. Since the resulting particles oxidize very rapidly, they are usually embedded in a metallic or nonmetallic matrix. The particles can be coined into shape, but are usually ground into a fine powder before being compacted into magnets.

As shown in the table, typical maximum energy products that can be obtained are 2.15 x 10^6 gauss-oersted for anisotropic ESD iron magnets and 3.5 x 10^6 gauss-oersted for anisotropic iron-cobalt magnets. Considerably higher values have been obtained in the laboratory. Since the theoretical maximum energy products of these materials are extremely high (up to 50 x 10^6 gauss-oersted), it is hoped that future developments will enable the materials to be used at their full potential.

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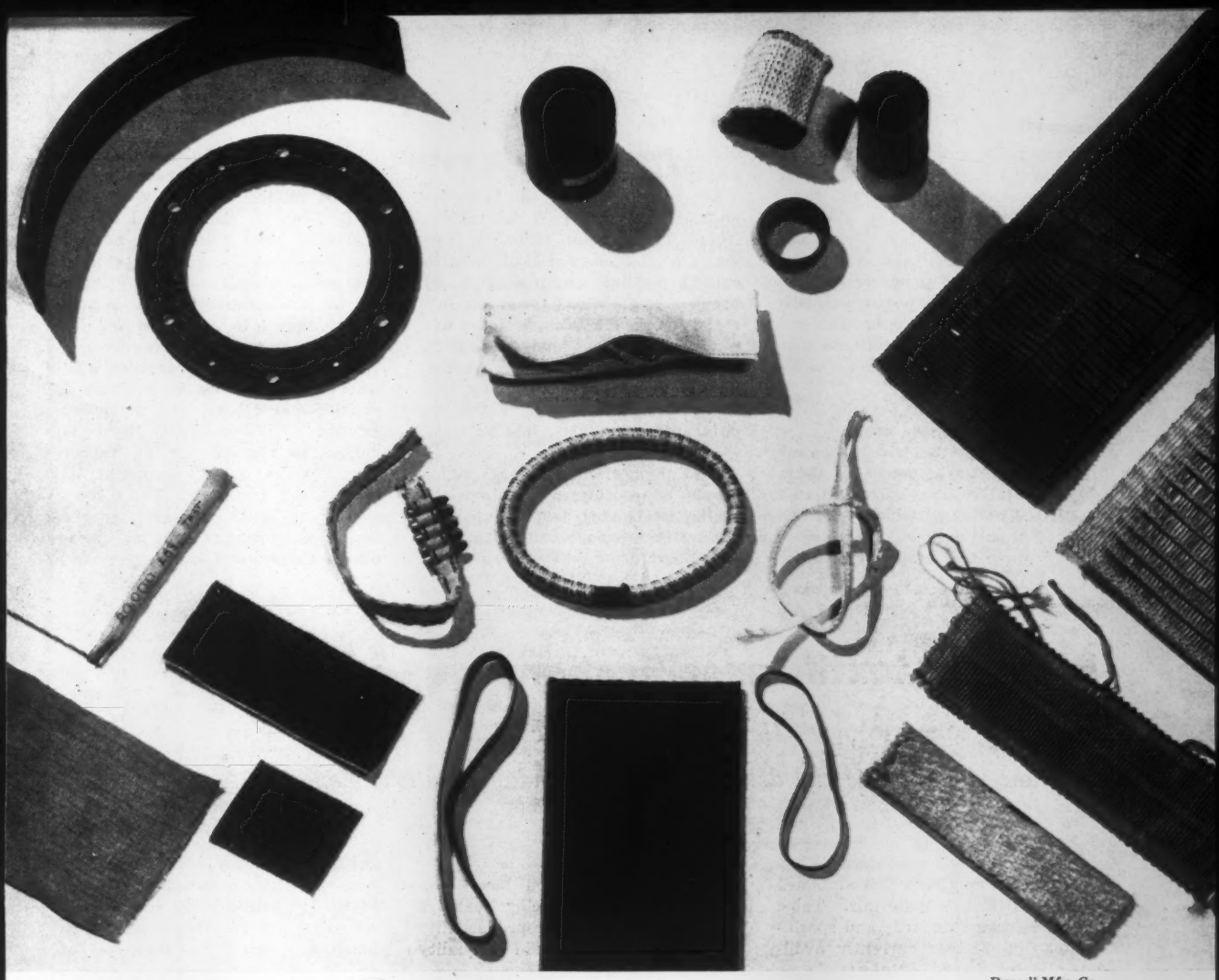

Russell Mfg. Co.

Mechanical uses *for textiles are shown by these "engineered" fabrics, based on a variety of fibers.*

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in Design Engineering

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Engineer's Guide to Industrial Textiles

Here is a guide to the properties of textiles, prepared for the nontextile engineer. It will help you work more intelligently with your textile supplier.

- *Properties of textile fibers*
- *Properties of textile forms, as affected by both fiber and form*
- *Textile forms available*
- *Glossary of textiles*

by **Malcolm W. Riley,** *Associate Editor, Materials in Design Engineering*

■ Properties of textiles depend not only on the fiber but on the form in which it is used—whether the form be a felt, a bonded fabric, a woven or knit fabric or cordage. Properties such as heat, chemical and weather resistance depend primarily on the type of fiber used; properties such as mechanical strength, thermal transmission, and air or liquid permeability depend both on the fiber and the textile form.

The versatility of textiles — in terms of properties obtainable — stems from 1) the wide range of fibers which can be used (see Table 2), and 2) the range of complicated textile structures which can be formed from the fibers. The box on p 117 describes briefly the basic textile forms, how they are made, and typical uses for each.

In general, some of the more important industrial uses for textiles include 1) insulation, including thermal, vibration, acoustical and electrical, 2) padding and packaging, 3) barrier applications such as air seals, etc., 4) filtration, both dry and wet, 5) upholstery and seating, 6) reinforcing for plastics or rubber, and 7) general mechanical applications, such as tenting, tarpaulins, parachutes, fish nets, marine lines, etc.

Two important factors which should be considered in discussing textile needs with textile suppliers, but which are not discussed here in detail are:

1. The types of finishes that can be applied. With the exception of finishes applied to obtain resistance to fire, water, mildew and micro organisms, most finishes are applied to garment and consumer textiles. Because of space limitations finishes are not discussed here. Textile producers should be consulted for information on specific finishes.

2. The combining of textiles with other materials, as in reinforced plastics and rubber, and in coated fabrics. The discussion here is limited to textiles *per se*, rather than textiles as a component of combination materials. The discussion is applicable, however, to the textile component of such multicomponent materials.

Planning textile specifications . . . selection

. . . terminology *Here's what you should know about selecting the right textile and developing understandable materials specifications.*

There are relatively few standard industrial textile materials. Table 1 summarizes standards and specifications on textiles currently available from governmental, trade or technical organizations. Beyond these, fabrics must be engineered to meet specific end-use requirements. A great deal of such "engineering" is still trial and error.

Rarely is the specific type of fiber and the textile form specified at the start by the end user. In most cases the end user relies on the experience of competent textile producers to select a fabric to meet his requirements. The most important responsibility of the end-use engineer in determining the proper textile is to accurately describe the operating requirements.

With this information, the textile producer attempts to isolate the specific engineering properties the textile must have. He then determines whether one of his standard textiles will meet the design needs, or whether a special fabric must be developed. As might be expected, fabric selection is not often simple. In many cases, several textiles must be service tested before the proper one is determined. When the proper fiber and textile form have been selected, materials specifications are drawn up to ensure reproducibility of the textile and to aid in quality control.

Textile specifications contain two important types of information: 1) descriptive information, and 2) service property requirements. (The glossary on p 129 explains common terms which are not explained in the following discussions.)

Descriptive specifications

Textile specifications usually contain information designed to physically describe the textile form. Such information includes 1) width in inches, 2) weight, usually in ounces per square yard, and 3) type of fiber.

Where a woven fabric is specified, specifications also usually include 1) type of weave, such as twill, broken twill, leno, or satin, 2) thread count, both in warp and filling (e.g., 68 x 44 denotes 68 warp yarns per in. and 44 filling yarns per in.), 3) whether a yarn is to be filament or staple, 4) crimp, in percent, 5) twist per inch, and 6) yarn numbers both for warp and fill.

Yarn number designations are somewhat complex. The glossary describes the yarn numbering systems used with various types of fibers. (Filament yarns are usually stated in denier.) Essentially, yarn numbers provide a measure of weight per unit length, or length per unit weight. A typical yarn designation on a specification may appear as 210 (denier)/ 1 x 20/2 (cotton system). This means that 1) the warp yarn is a 210-denier single yarn, and 2) the filling yarn contains 2 plies, each of which is a 20 singles yarn (determined by the cotton numbering system).

Also, a number of somewhat irrational fabric designation systems have been formalized by tradition over the years. For example, sheetings, drills, twills, jeans, broken twills and sateens are designated by width in inches, number of linear yards per pound, and number of warp and filling threads per inch (e.g., 59″ 1.85 68 x 40 drill). Specs for equivalent synthetic fabrics also include fiber type, and whether staple or filament.

Single and double filling and army ducks are generally identified by width, ounces per linear yard, warp and filling count, e.g., 28½″ 8 52½ x 42 army duck). Cotton belt duck

(text continued on p 119)

Industrial Textile Forms—and Where They Are Used

Textile engineering materials can be classified generally as 1) nonwoven fabrics, including both felts and bonded fabrics; 2) woven or knit fabrics; and 3) cordage.

Nonwoven fabrics

Felts, whether made of wool or synthetic fibers, are formed by the purely mechanical interlocking of fibers. Wool and some other natural fibers have a tendency to curl. When agglomerated and agitated under heat, moisture and pressure, and then shrunk, they entangle and interlock, forming a strong three-dimensional fabric. Wool fibers also have microscopic surface scales which act as barbs in helping to lock the fibers together.

Synthetic fibers do not have this natural curling tendency, and their surfaces are usually smooth. A so-called "needle batting" process is used to mechanically interlock such fibers. A barbed needle is forced into a batt of fibers, and on withdrawal entangles the fibers. In production, there may be as many as 1000 needle penetrations per sq in. After the fibers are interlocked, the felt is usually shrunk to provide a strong three-dimensional bond.

Bonded fabrics consist of fibers which have been either 1) bonded under heat and pressure with an adhesive binder such as rubber, latex or a synthetic resin, or 2) bonded with a thermoplastic fiber, which is incorporated in the fibrous mass and fused with heat.

Woven and knit fabrics

The basic building blocks of woven or knit fabrics are fibers. Fibers may be either filament (extremely long) or staple (relatively short). From these fibers either filament or staple yarns are produced.

Filament yarns are primarily used for maximum strength.

Staple yarns are produced by spinning staple fibers into long continuous strands. Friction caused by the twist holds the staple fibers together in the yarn. Two or more of these so-called "single yarns" may then be twisted together to form "ply yarns." Ply yarns, in turn, can be twisted together to form "cabled yarns" or "cord."

Yarns are either knit or woven to form fabrics. Knitting is a process of interlocking one or more yarns, and, except for some knit textiles used for coated fabrics, is little used for industrial fabrics. Knitting generally provides a fabric of greater bulk and extensibility than weaving.

Weaving is the process of interlacing lengthwise "warp" yarns with crosswise "filling" yarns in any of a variety of constructions. All woven fabrics are variations of three basic weaves:

1. *Plain weave* is simply "one yarn up and one down." Tightly woven, a plain weave can provide the most yarn-interlacings per square inch, and thus maximum "cover" and impermeability. The weave can also be "opened up" to practically any desired degree.

2. *Twill weave* is characterized by a sharp diagonal "twill line" produced by the warp yarn crossing over two or more filling yarns, with interlacing advancing one filling yarn with each warp. More porous than an equivalent plain weave, twills are used in drill fabrics and jeans.

3. *Satin weave* is characterized by regularly spaced interlacings at wide intervals. Satins provide porosity, good cover, and a smooth surface. Originally woven from silk yarn, satin weave is called "sateen" when woven from cotton.

The accompanying illustrations show the basic weaves.

Cordage

The term cordage includes all types of threads, twine, rope and hawser. Essentially all cordage consists of fibers twisted together, plied, and in many cases cabled to produce essentially continuous strands of desired cross section and strength.

In addition to the type of fiber used, the most important determinants of the end properties of cordage are the type and degree of twist employed. The two major types of twists are: 1) cable twist, in which the direction of twisting is alternated in each successive operation, i.e., singles may be "S" twisted, plies "Z" twisted and cables "S" twisted (see "Twist" in glossary for description of "S" and "Z" twist), and 2) hawser twist, in which the singles, plies and cables are twisted "SSZ" or "ZZS." Hawser twist generally provides higher strength and resilience.

Where they're used

Some indication of where each textile form is typically used may be helpful.

Typical uses for nonwoven fabrics (felts and/or bonded fabrics) include: 1) processing aids, such as papermaker's felts, 2) filtration, 3) vibration isolation, such as machine mounts and packaging of china, 4) friction materials, such as brake linings and buffing and polishing, 5) sealing, both for liquid retention and for exclusion of dirt, 6) thermal insulation, and 7) such specialty applications as wicking of lubricants or inks.

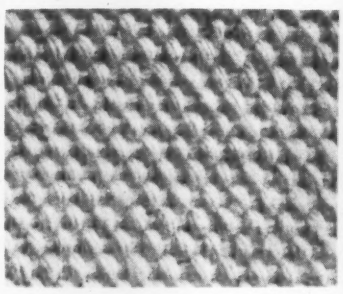
Typical uses for woven fabrics include 1) mechanical applications, such as belting, upholstery, tenting, parachutes, and reinforcement for plastics and rubber, 2) filtration, and 3) packaging.

Typical uses for cordage include tire cords, rope and hawsers, and netting of all types.

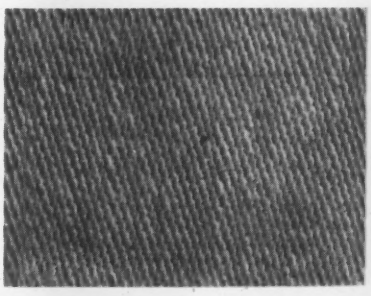
Three types of woven fabrics

Source: Wellington Sears Co.

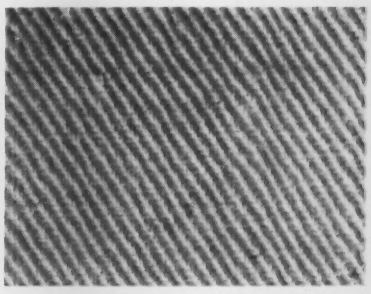
Plain weave (belt duck)



Satin weave (sateen)



Twill weave (twill)



Engineered Textiles: A New Approach

For the most part, the design of industrial textile materials is an art. Over the last few years, however, a more scientific approach to textile structures as engineering materials has been emerging. Ultimately such an approach should lead to the engineering of textile fibers of known properties into composite textile structures of precise and predetermined properties.

Such a technology is extremely complex because of the complex nature of textiles. Actually, each fiber is a "microscopic beam"—an independent structural entity, but one that is never used alone.

According to *Hamburger*, the major factors affecting the properties of woven textiles, for example, are the properties of the fiber, the yarn and the fabric in each particular woven configuration. These properties in turn are primarily determined as follows:

A. Fiber properties by:
   1. Polymer properties.
   2. Geometric modifiers, which depend on:
      a. Orientation of molecules within the fibers.
      b. Cross-sectional area and shape.
      c. Length.
      d. Crimp.
      e. Surface contour.

B. Yarn properties by:
   1. Fiber properties.
   2. Geometric modifiers which depend on:
      a. Fineness.
      b. Twist.
      c. Cross section, determined by:
         1) Diameter.
         2) Compactness.
      d. Surface character.

C. Fabric properties by:
   1. Yarn properties.
   2. Geometric modifiers, which depend on:
      a. Tension on yarn components, determined by:
         1) Tension on elements in weaving process.
         2) Compactness of weave.
      b. Weave design.

The above listing indicates the complex interrelations among fibers, yarns and fabrics, and the difficulty in developing a classical engineering approach.

According to *Kaswell*, researchers have taken two major approaches to the problem of analyzing the effect of fabric geometry on end properties. The first, and most difficult, is a theoretical analysis of ideal geometric structures. The second is the empirical investigation of the effect of geometry on physical properties.

In developing the first approach, mathematical formulas have been established for the geometry of single and plied yarns, and relationships established between helix angle, single and ply twist, and single and ply diameters as they affect physical properties.

Another study relates eleven structural parameters which control construction of a fabric. Any seven of these parameters may be related by simultaneous equations, leaving four variables available for process control. The importance of such an analysis lies in the fact that fabrics can be engineered in terms of yarn size and spacing, fabric thickness, density, opacity, crimp, etc. These factors, in addition to inherent fiber properties, govern end properties of textiles.

In spite of the encouraging progress to date, a great deal of work remains to be done. A complete classical textile engineering technology is still far in the future.

TABLE 1—SUMMARY LIST OF STANDARDS AND SPECIFICATIONS FOR TEXTILES[a]

Organization	Type of Document	Document Identification[b]	Materials, Forms, Uses
WOVEN ORGANIC YARNS, FABRICS			
ASTM	Spec	DXXX	Cotton. Cloth, tape. Electrical uses
ASTM	Spec	DXXX	Cotton. Cloth, sheeting, tape. General and electrical uses
ASTM	Spec	DXXX	Cotton, rayon, nylon, fibrous glass. Flexible treated sleeving. Electrical uses
Federal	Spec	DDD-T-86	Cotton. Tape. General uses
Federal	Spec	HH-C-471	Varnished cotton. Cloth, tape. Electrical uses
Federal	Spec	HH-I-528	Cotton. Batt. Thermal insulation
Military	Spec	JAN-T-414	Cotton. Tape
Military	Spec	MIL-C-5646	Cotton. Cloth. Aeronautical uses
Military	Spec	MIL-I-XXX	Cotton rayon, synthetic. Fiber, yarn, cloth, tape. Electrical uses
Military	Spec	MIL-T-XXX	Cotton, rayon-cotton. Tape
NEMA	Std	VFX	Cotton. Cloth, tape. Electrical uses
NEMA	Std	48-140	Varnished silk. Cloth. Electrical uses
SAE	Mtl Spec	AMS 38XX	Cotton. Cloth (mercerized). Aeronautical uses
FELTS			
ASTM	Spec	DXXX	Mechanical sheet and roll felts. General uses
Comm. Dept.[c]	Comm. Std.	CS185	Wool felt. General uses
Federal	Spec	C-F-XXX	Pressed wool felt, hair felt. General uses
Federal	Spec	HH-I-XXX	Laminated felt, asbestos felt. Thermal insulation
Military	Spec	MIL-I-XXX	Asbestos felt, glass fiber felt. Thermal insulation
Military	Spec	MIL-F-XXX	Hair felt, wood fiber. Aeronautical and general uses
SAE	Std	—	Mechanical roll felt. Automotive and general uses
ASBESTOS			
ASTM	Spec	D299[d]	Yarn. Electrical uses
ASTM	Spec	DXXX	Cloth, tape, roving. Electrical uses
Federal	Spec	HH-I-561	Thermal insulation
Federal	Spec	SS-C-466	Cloth, thread, tape. Electrical uses
Military	Spec	MIL-C-4117	Cloth, tape. Electrical uses
SAE	Mtl Spec	AMS 3840	Polytetrafluoroethylene-impregnated. Aeronautical uses
GLASS			
NEMA	Std	GFX	Yarn, staple, filament. Electrical uses
NEMA	Std	VFX	Glass fiber cloth. Electrical uses
Military	Spec	MIL-G-XXX	Glass fiber cloth (coated and uncoated)
Military	Spec	MIL-I-XXX	Fibrous glass. Thermal insulation
Military	Spec	MIL-I-XXX	Glass fiber cloth, tape. Electrical uses
Military	Spec	MIL-T-XXX	Glass fiber tape
SAE	Mtl Spec	AMS 3676	Resin-bonded glass fiber filament. Acoustica and thermal insulation. Aeronautical uses
SAE	Mtl Spec	AMS 36XX	Glass fiber cloth. Aeronautical uses

[a]List includes only materials specifications; no product specifications are included.
[b]XXX in the document identification indicates that more than one standard has been developed on the material. Revisions, amendments and year are not indicated. When the document is ordered, the latest issue is supplied.
[c]Also Felt Assn.
[d]American Standard ASA L14.18.
Source: Kaidanovsky, S.P., "Guide to Materials Standards and Specifications, Part 5," M/DE July '58, p 93.

(text cont'd from p 116)

weights, regardless of actual width, are based on a 42-in. width; hose duck weights are based on a 40-in. width.

"Numbered" ducks are designated by width and arbitrary number classifications. No. 1 duck weighs 29.46 oz per sq yd; No. 12 duck weighs 11.45 oz per sq yd. "Naught" ducks are numbered from 1/0 to 12/0, and weigh over 48 oz per sq yd.

Service property requirements

Where a textile must meet specific design requirements, these requirements are often spelled out in the specification in terms of properties of the textile. Service properties of textiles can be classified as 1) properties solely dependent on the fiber used, and 2) properties dependent on both fiber and textile form.

The rest of this manual is organized by end properties of textiles. Properties solely dependent on the fiber—resistance to heat, cold, chemicals and weather—are given in specific property ranges. Properties dependent on both fiber and textile form are impossible to tabulate meaningfully for all types of textiles. For such properties, therefore, the discussion includes 1) an indication of the relative importance of fiber vs form in determining the property of the textile, and 2) a brief description of the standard tests used to measure the property and the units in which properties are most commonly reported.

This approach should 1) help you discuss your textile needs more intelligently with the textile producer in terms you both can understand, and 2) give you a general indication of some property ranges obtainable in textiles.

TABLE 2—TYPICAL PROPERTIES OF TEXTILE FIBERS

Type →	Natural Organic										
		Best Fibers				Hard Fibers			Animal Fibers		
	Cotton	Flax	Jute	Hemp	Ramie	Manila (abaca)	Sisal	Henequin	Wool	Horsehair	Silk
NATURE OF FIBER											
Length, in.	½-2½	6-40	10-60	40-80	15-25	20-40	24	20	1½-15	1-25	Filament
Width, μ	17	16	17	20	47	19	19	20	28	100	11
Cross section	Flat tube	Tube	Bunched cells	—	Flat tube	Bunched cells	Bunched cells	Bunched cells	Round	Round	Round
PHYSICAL AND MECHANICAL PROPERTIES											
Specific Gravity	1.55	1.50	1.48	1.48	1.55	—	—	—	1.30	1.30	1.25-1.35
Breaking Tenacity, gm/den											
70 F, 65% RH	3.0-4.9	6.3	3.0-5.9	5.9-6.9	6.5	6.0-7.5	4.1	3.0-3.5	1.0-1.7	—	2.8-5.2
Wet	3.3-6.37	—	—	—	—	6.0-8.5	—	2.5-3.0	0.76-1.63	—	2.1-4.9
Ten Str (70 F, 65% RH), 1000 psi	44-109	115	57-112	112-132	130	125	100-120	—	20-29	—	45-83
Breaking Elongation, %											
70 F, 65% RH	3-7	3	—	2-6	3-6	2-3	2-2.5	—	25-35	—	13-31
Wet	—	—	—	—	—	—	—	—	25-50	—	—
Stiffness (avg), gm/den[a]	57-60	270	185	200	167	175	127	—	3.9	—	18
Strain Recovery (at 2%), %[b]	74, 45 (5%)	65	74 (1%)	—	52	—	—	—	99, 63 (20%)	99, 63 (20%)	92
Toughness (avg), gm-cm/den-cm	0.15	0.09	0.03	—	—	—	—	—	0.25	—	0.44
Moisture Regain (70 F, 65% RH), %	7	12	13.75	11.75	12	—	—	—	16	—	11
RESISTANCE TO ENVIRONMENTS											
Acids											
Strong	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Good[m]	—	Poor
Weak	Poor (hot)	Poor	—	Poor	—	—	—	—	Good	—	Fair
Alkalis											
Strong	Exc	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Poor
Weak	Exc	Good	Good	Good	Good	Good	Good	Good	Attacked	Poor	Poor (hot)
Other Chemicals	Show generally good resistance to organic solvents; cotton bleached by hyperchlorites and peroxides; swells and disintegrates in cuprammonium hydroxide								Bleached by peroxides or SO_2	Resistant	Resistant
Heat	Good to 275 F	Good to 275 F	—	Good to 275 F	Good to 275 F	—	—	—	Good to 212 F	—	Disintegrates at 340 F
Sunlight (prolonged exposure)	Weakened	None	None	None	None	None	None	None	Weakened	Weakened	Weakened
Microorganisms	Poor	Very good	Good	Good	Exc	Good	Poor	Poor	Fair	Fair	Good
Flame[c]	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Slow burn	Slow burn	Burns

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.
[m] Except hot H_2SO_4.

table continues on p 120

Properties . . . heat resistance . . . effects of cold . . . chemical resistance . . . weather resistance

In a textile fabric, these properties are solely dependent on the type of fiber. Here's how the various fibers stack up.

Heat Resistance

Where heat is to be encountered in service, the high temperature service limits of various fibers can be used for initial screening, since the heat resistance of a textile is primarily dependent on the heat resistance of its fibers. In the case of bonded fabrics, heat resistance is a function of the binder.

Heat resistance of the various fibers is shown in Table 2. Values used in reporting maximum service temperatures are not all directly comparable. Also, because heat affects different fibers in different ways, temperature values given here are primarily intended to establish approximate orders of resistance.

TABLE 2—TYPICAL PROPERTIES

Type ➡	Synthetic Organic							
	Regenerated Cellulose (rayons)						Cellulose Esters	
	Viscose				Saponified Acetate			
	Regular	Medium Tenacity	High Tenacity	Cuprammonium	Fortisan	Fortisan 36	Cellulose Acetate	Cellulose Triacetate (Arnel)
NATURE OF FIBER								
Length, in.	Staple, filament		Filament	Filament	Filament		Staple, filament	Staple, filament
Width, μ	10-43	8.4-43	10-15	11	3-9		11-46	—
Cross section	Irregular	Irregular	Irregular	Round	Irregular		Clover leaf	Clover leaf
PHYSICAL AND MECHANICAL PROPERTIES								
Specific Gravity	—	1.46 to 1.52	—	1.52-1.54	1.5	1.5	1.32	1.3
Breaking Tenacity, gm/den								
70 F, 65% RH	1.5-2.4	2.4-3.2	3.0-5.0	1.7-2.3	6-7	8	1.3-1.5	1.2-1.4
Wet	0.7-1.4	1.2-1.9	1.9-3.6	0.95-1.35	5.1-6.0	6.0-6.4	0.8-1.2	0.8-1.0
Ten Str (70 F, 65% RH), 1000 psi	29-46	46-65	65-105	33-45	136	155	22-28	20-26
Breaking Elongation, %								
70 F, 65% RH	15-30	15-20	9-22	10-17	6	6.2	23-34	22-28
Wet	20-40	17-30	14-30	17-33	6	6	30-45	30-40
Stiffness (avg), gm/den[a]	11.1	16.6	25.5-29	15.5	117	135	5.5	5.2
Strain Recovery (at 2%), %[b]	30-74 (4%)	97	70-100	17-75	100 (20%), 60 (40%)	85, 70 (5%)	48-65 (4%)	88 (3%), 43 (10%)
Toughness (avg), gm-cm/den-cm	0.19	0.21	0.22-0.30	0.14	0.21	0.26	0.17	0.16
Moisture Regain (70 F, 65% RH), %	13	13	13	11	10.7	9.6	6	3.2
RESISTANCE TO ENVIRONMENTS								
Acids								
Strong	Similar to cottons, i.e., disintegrated by hot dilute or cold concentrated acids			Similar to cotton	Similar to cotton		Decomposed	Similar to acetate
Weak							Good	
Alkalis								
Strong	Swell; strength reduced			Similar to viscose	Similar to cotton		Saponifies	Saponifies
Weak	Good			Good			Res (cold)	Res (cold)
Other Chemicals	Attacked by strong oxidizing agents; not damaged by hypochlorite or peroxide bleaches			Not attacked by oxidizing agents; not damaged by bleaching solutions	Similar to cotton		Similar to viscose	Similar to viscose
Heat	Lose strength at 300 F. Decompose at 350-400 F			Decomposes at 300 F	Similar to cotton		Sticky at 350-375 F; softens at 400-475 F; melts at 500 F	When heat treated will not stick at 480 F; melts at 575 F
Sunlight (prolonged exposure)	Weakened			Resistant	Resistant		Weakened	Weakened
Microorganisms	Attacked			Attacked	Attacked		Resistant	Resistant
Flame[c]	Highly flammable			Highly flammable	Burns		Burns slowly	Burns slowly

[a]Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b]Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[c]Basic flammability of untreated fiber.
[g]Copper block method.
[l]For filament; 35-40% for staple.

As expected, inorganic fibers have the highest heat resistance. A newly announced graphite fiber (not included in Table 2 because of lack of data) has the highest heat resistance of all fibers when protected from oxidation. With such protection tensile strength of the fiber actually increases with temperature up to a maximum of about 15,000 psi at 4500 F.

Maximum continuous use temperatures of other inorganic fibers are approximately as follows: aluminum silicate, 2300 F; pure quartz, 2000 F; 96% silica glass, 1850 F; asbestos, about 1000 F; and borosilicate glass (commercial "E" type), 600 F.

In descending order of heat resistance, synthetic organic fibers as a class come next and overlap with the natural fibers. TFE fluorocarbon (Teflon) has a maximum service temperature of about 500 F. The other synthetic organics are difficult to classify specifically, as they are thermoplastic and gradually soften on heating. However, in general, maximum use temperatures of the acrylics (including the newer dinitrile and nitrile alloy fibers), cellulose esters, nylons, isotactic polypropylene and high density polyethylenes fall in the range of 450 to 300 F.

Of the natural fibers, silk may be the closest to this temperature range; silk is reported to disintegrate at about 340 F. Viscose rayons lose strength at 300 F. Cotton and bast fibers, and cuprammonium and saponified acetate rayons, are generally satisfactory at temperatures up to about 275 F. Vinyl-type fibers melt or soften in the 280-240 F range. Wool is generally considered to be useful up to about 212 F.

Low temperature resistance

Relatively little information is available on effects of low temperatures on fibers. As would be expected from the characteristics of the raw materials, inorganic fibers remain virtually unaffected. Synthetic organic fibers usually tend to stiffen and embrittle; elongation diminishes and strength increases.

OF TEXTILE FIBERS—continued

Synthetic Organic (continued)

	Polyamides						Acrylics				
	Nylon 66			Nylon 6							
	Regular	High Tenacity	Staple	Regular	High Tenacity	Staple	Polyacrylonitrile (Orlon)	Acrylonitrile-Vinyl Derivatives (Acrilan)	Acrylonitrile-Vinyl Chloride (Dynel)	Modified Acrylic (Verel)	Acrylonitrile-Base (Creslan)
	Filament		Staple	Filament		Staple	Staple	Staple	Staple	Staple	—
	11-43 Round	16-43 Round	14-43 Round	— Round		— Round	14-27 Dogbone	15-30 —	— —	— —	— —
Specific gravity	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.17	1.3	1.37	1.17
Tenacity, g/d	4.6-5.9	5.9-8.8	4.0-4.7	4.5-5.8	6.8-8.6	3.8-5.5	2.2-2.6	2.5	2.5-3.3	2.5-2.8	3.3
Elongation, %	4.0-5.2	5.1-7.6	3.5-4.2	4.3-5.3	5.4-7.5	—	1.8-2.1	2.0	2.5-3.3	2.4-2.7	3.3
Initial modulus	67-86	86-128	58-69	73-84	109-125	70-80	32-39	37-40	40-57	42-47	41
Moisture regain, %	26-32	18-28	38-42	24-34	16-17.5	37-40	20-28	36	30-42	33-35	32
Moisture content, %	30-37	21-32	42-46	28-38	19-24	42-46	26-34	44	42-30	32-34	32
Water imbibition, %	18	32	10	23	48	17-20	10	7	8.2	8.0	10.3
Boiling water shrinkage, %	100, 100 (8%)	100 (4%)	—	100, 100 (8%)	100 (4%)	100	—	99, 89 (5%)	94	88 (4%), 55(10%)	90 (1%), 48 (5%)
Dry heat shrinkage, %	0.76	0.85	0.87	0.67	0.75	0.64-0.78	0.40	0.46	0.53	0.46	0.53
Dry heat shrinkage temp, F	4.5	4.5	4.5	4.0	4.0	4.0	1.5	1.2	0.3-0.4	3.5-4	1.3
Effect of mineral acids	Dissolves in cold HCl, H_2SO_4 and HNO_3			Degraded by oxidizing agents and mineral acids			Good-exc	Good-exc	Good	Exc	Good-exc
Effect of organic acids	Ultimate disintegration in 5% boiling HCl			Weakens on prolonged exposure to acids such as benzoic and oxalic			Exc	Exc	Exc	Exc	Exc
Effect of alkalies	Inert			Inert			Poor	Poor	Good	Discolors some, no weakening	Poor
Effect of bleaches	Inert			Inert			Fair-good	Fair-good	Exc		Fair-good
Effect of solvents	Good			Good			Not harmed by solvents, oils, greases and some acid salts	Similar to Orlon	Good; softened by acetone and some ketones	Good; dissolves in warm acetone	Good
Effect of heat	Yellows slightly after 5 hr at 300 F; melts at 482 F			Yellows slightly after 5 hr at 300 F; melts at 420 F			No weakening after 32 days at 257 F; sticking temp 455 F	5% shrinkage at 487 F	Unless heat treated, shrinks at 250F	Exposure over 300 F causes stiffening	Sticking temp 450 F
Effect of sunlight	Weakened			Weakened			Very resistant	Resistant	Weakened	—	—
Effect of weathering	Resistant			Resistant			Resistant	Resistant	Resistant	—	—
Flammability	Self-exting			Self-exting			Burns slowly	Burns slowly	Self-exting	Self-exting	Burns

Trademarks: Fortisan, Arnel, Creslon—Celanese Corporation of America; Orlon, Dacron, Teflon—E. I. du Pont de Nemours & Co., Inc.; Acrilan—Chemstrand Corp.; Verel—Tennessee Eastman Co.; Dynel—Union Carbide Chem. Co.; Darvan—B. F. Goodrich Chem. Co.; Zefran—Dow Chem. Co.; Vinyon—Union Carbide Chem. Co. (polymer), American Viscose Corp. (fiber); Vinylon—International designation, Air Reduction Chem. Co. in U. S.; Fiberfrax—Carborundum Co.

table continues on p 122

However, it is difficult to predict the results of such changes on other properties. For example, energy absorption may be affected, but not necessarily decreased, by decrease in temperature. Energy absorption is equivalent to the area under the stress-strain curve. Consequently, the effect of cold on the *shape* of the stress-strain curve—not its effect on ultimate strength and elongation values alone—will determine effect on energy absorption.

Chemical resistance

The best way of picking a fiber for use in any specific chemical environment is to try it. However, general chemical stability of the fibers can be outlined to help in initial screening. More specific summaries of chemical stability are given in Table 2.

Graphite, quartz, TFE fluorocarbon and certain glass fibers are probably the most inert. Graphite is unattacked by all acids, alkalis and organic compounds except those which are highly oxidizing. TFE fluorocarbon is inert to all chemicals but alkali metals and certain halogens and halogenated chemicals at elevated temperatures and pressures. Glasses resist all acids but hydrofluoric and hot phosphoric, but are usually attacked by strong alkalis, particularly at elevated temperatures. Chemical resistance of common glass fibers is generally directly proportional to the amount of silica in the glass. Thus chemical resistance decreases in the following order: silica (quartz), 96% silica, borosilicate, and soda lime.

Asbestos has fair to good (depending on type) resistance to acids and alkalis.

Vinyl-type fibers, polyethylene and polypropylene probably have the best all-around resistance of the synthetic organics, with the exception of TFE. Among the acrylics, acry-

TABLE 2—TYPICAL PROPERTIES

Type →	Synthetic Organic (continued)								
	Acrylics (cont'd)		Polyester			Vinyl Derivatives			
	Dinitrile[d] (Darvan)	Nitrile[e] Alloy (Zefran)	Polyethylene Terephthalate (Dacron)			Vinyl Chloride-Acetate (Vinyon)	Vinylidene Chloride (saran)		
			Regular	High Tenacity	Staple		Monofilament	Filament	Staple
NATURE OF FIBER									
Length, in.	—	—	Filament		Staple	Staple	—	—	—
Width, μ	—	—	11-28		18-25	16-18	1300	50	—
Cross section	—	—	Circular		—	Barbell	Circular	Circular	Circular
PHYSICAL AND MECHANICAL PROPERTIES									
Specific Gravity	1.18	1.19	1.38	1.38	1.38	1.33-1.35	1.7	1.7	1.7
Breaking Tenacity, gm/den									
70 F, 65% RH	1.75	3.5	4.4-5.0	6-7	3.8-4.3	0.7-1.0	1.2-2.3	Up to 2	Up to 1.5
Wet	1.5	3.1	4.4-5.0	6-7	3.8-4.3	0.7-1.0	1.2-2.3	Up to 2	Up to 1.5
Ten Str (70 F, 65% RH), 1000 psi	26	53	77-88	106-123	67-76	12-17	15-45	44	33
Breaking Elongation, %									
70 F, 65% RH	30	33	19-25	9-11	30-36	100-120	20-30	15-25	15-25
Wet	30	33	19-25	9-11	30-36	100-120	20-30	15-25	15-25
Stiffness (avg), gm/den[a]	6	11	21	65	12	1.5	7-10	8-12	8-12
Strain Recovery (at 2%), %[b]	100 (3%), 75 (5%)	99, 72 (10%)	97, 80 (8%)	100, 90 (8%)	—	—	95 (10%)	95 (10%)	95 (10%)
Toughness (avg), gm-cm/den-cm	0.3	0.58	0.78	0.50	1.03	1.3	0.17-0.27	0.125	0.125
Moisture Regain (70 F, 65% RH), %	2-3	2.5	0.4	0.4	0.4	Up to 0.5	None	None	None
RESISTANCE TO ENVIRONMENTS									
Acids									
Strong	Good-Exc	Exc	Dissolves in H_2SO_4			Exc	Exc; fair to conc H_2SO_4		
Weak	Exc	Exc	Good			Exc	Exc		
Alkalis									
Strong	Poor	Fair	Disintegrates when boiled			Exc	Exc except for amomnium hydroxide		
Weak	Fair-good	Good	Good			Exc	Exc		
Other Chemicals	Good	Good	Good			Soluble in some chlorinated hydrocarbons	Some effect from esters and others		
Heat	Unaffected by 195 days at 300 F; sticking temp 340 F[g]	Sticking temp 490 F[g]	Melts at 480 F			Tacky, shrinks at 150 F, softens at 170 F, melts at 260 F	Softens at 240-280 F		
Sunlight (prolonged exposure)	Resistant	Resistant	Weakened			Resistant	Tends to yellow		
Microorganisms	Resistant	Resistant	Resistant			Resistant	Resistant		
Flame[c]	Burns	Burns	Burns slowly			Self-exting	Self-exting		

[a] Ratio of breaking stress to breaking strain (i.e., gm/den to rupture divided by strain in cm/gage cm at breaking stress).
[b] Recovery after 2% strain, except where specific percentage strain is given in parentheses.
[c] Basic flammability of untreated fiber.
[d] Though not an acrylic (actually a polymer of vinylidene cyanide), it is grouped here because of similarities of properties.
[e] Nitrile "alloy" based on acrylonitrile.
[f] Properties may vary widely depending on glass composition; values here indicative of those of borosilicate.
[g] Copper block method.
[h] Data are unavailable for a newly announced graphite fiber.

lonitrile-vinyl chloride (Dynel) and the modified acrylic (Verel) are little affected by most chemicals; fibers such as polyacrylonitrile (Orlon) and acrylonitrile-vinyl (Acrilan) have excellent resistance to some acids, but are attacked by strong alkalis.

Polyester fibers (Dacron) have generally good resistance to weak acids and alkalis, and fair to good resistance to strong alkalis and acids at low temperatures.

Nylons have excellent resistance to petroleum oils, good resistance to alkalis, and fair to poor general acid resistance (depending on concentration and type of acid).

Rayons, cellulose esters and the natural fibers have generally poor acid resistance and, except for protein fibers, relatively good alkali resistance (actually alkali resistance ranges from excellent for cotton to saponification by strong alkalis for cellulose esters).

Weatherability

Inorganic fibers are for the most part unaffected by weathering. Among the synthetic organic and natural fibers, where inherent weatherability of the fiber is poor but other considerations dictate its use outdoors, a variety of finishing treatments and coatings are available to provide necessary weatherability.

The discussion here is primarily concerned with inherent weatherability of fibers.

Of the organic fibers, TFE fluorocarbon is completely inert to effects of weather, and the natural bast (e.g., flax, jute, hemp and ramie) and hard fibers (e.g., manila, sisal and hennequin) are essentially unaffected.

Polyacrylonitrile (Orlon) and vinyl chloride-acetate (Vinyon) have excellent resistance to weathering. Other acrylics are resistant, though some show slight losses in tensile

OF TEXTILE FIBERS—concluded

Synthetic Organic (continued)					Inorganic[h]		
Polyvinyl Alcohol (Vinylon)	TFE Fluorocarbon (Teflon)	Polyolefins: Polyethylene Type I	Polyolefins: Polyethylene Type III	Polypropylene	Glass[f]	Asbestos (chrysotile)	Aluminum Silicate (Fiberfrax)
Staple — Peanut	Filament — Circular	Monofilament 250-1300 Circular		Monofilament — Circular	Filament, staple 5-16 Circular	Crude ⅛-2 in. 0.1 —	¼-10 in. staple 2-20 (mean) —
1.26-1.30	2.3	0.92	0.95-0.96	0.90-0.91	2.54	2.4-2.6	2.73
4.4-6.0	1.6	1.0-3.0	5.0-7.3	5.5-7.0	6.0-7.3	2.5-3.1	1.4-6.5[o]
3.7-5.0	1.6	1.0-3.0	5.0-7.3	5.5-7.0	3.9-4.7	—	—
—	47	11-35	50-90	—	200-220	80-100	50-230
15-17	13	20-80	10-40	12-25	2.0-3.75	—	1.4-2.7[o]
—	13	20-80	10-40	—	—	—	—
24-40	12	2-12	20-50	—	322	—	—
—	—	90.95 (5%)	Slow	—	100 (3%)	—	—
0.79-0.92	0.12	0.3	—	—	0.07	—	—
4.5-5.0	None	None	None	—	0	—	—
—	Inert	Exc to all but oxidizing		Similar to polyethylene	Attacked only by hydrofluoric and hot phosphoric	Good (cold) to poor (hot)	Seems to have chemical resistance similar to borosilicate glass fibers
—					Stable	Good (cold) to poor (hot)	
—	Inert	Exc	Exc	Exc	Resists most	Good	
—	Inert	Exc	Exc	Exc	Resists most	Good	
—	Only affected by alkali metals and some hot, pressurized halogenated hyd.	Some swelling and weakening in benzene, toluene, etc.		Similar to polyethylene	Exc	—	
Melts 420-450 F	Nondegraded at 400 F; extremely slow sublimation at 550 F	Melts at 225 F	Melts at 265-280 F	Melts at 325-335 F	600-2000 F[j]	750-1490 F[l]	2300 F max use temp; 3300 F melting point
—	Inert	Resistant if pigmented		Resistan tif pigmented	Inert[k]	Inert	Inert
Resistant	Inert	Resistant		Resistant	Unaffected	Unaffected	Unaffected
Burns slowly	Self-exting	Burns slowly		Burns slowly	Nonflammable	Nonflammable	Nonflammable

[j]Normal glass limited to 600 F; quartz fiber generally useful up to 2000 F, though some shrinkage occurs.
[k]Specific types available with excellent weathering characteristics.
[l]Structure is stable up to 1490 F; at temperatures of 750 F and above, substantial amounts of water of crystallization are lost.
[n]Average is 3.3 gm/den.
[o]Average is 1.7%.
Source: Adapted from 1) "Man-Made-Fiber Table", *Textile World*, Sept'57; 2) *Harris;* 3) Miner, D.F., Seastone, J.B., *Handbook of Engineering Materials*, John Wiley & Sons, Inc., 1955; and supplier's literature.

Mechanical applications . . .

American Metal Products Co.: E. I. du Pont de Nemours & Co., Inc.

Nonlubricated bearing *uses low friction of TFE fluorocarbon (Teflon) in woven fabric form. Fabric forms face of the joint socket.*

E. I. du Pont de Nemours & Co., Inc.

Marine cordage *requires strength, abrasion resistance, and resistance to weather and water. Here nylon rope provides additional benefit of light weight.*

strength. Vinylidene chloride darkens slightly with no loss in strength.

Polyester and nylons show some loss of strength on prolonged exposure, but no discoloration.

Polyethylene and polypropylene, in natural colors, lose strength on exposure to weathering. Compounding with colored pigments substantially improves performance (black providing maximum weatherability).

Rayons and acetates lose tensile strength on prolonged exposure. Of cotton, silk and wool fibers, all of which lose strength on prolonged exposure, wool is the least affected, followed by cotton and silk in that order.

Properties . . . mechanical properties . . . abrasion resistance . . . thermal transmission . . . gas permeability . . . liquid permeability . . . tactile properties

Here's how the type of fiber and the form affect these properties, and the tests used to measure and report these properties.

Mechanical properties

The relationship between mechanical properties of fibers and the textile form into which they are felted, bonded, twisted or woven is obviously complex. The intricate configurations the fibers assume within a textile, directly affect the way in which the fibers are stressed.

One generalization can be made: For a woven fabric of a given weave, other things being equal, strength in tension depends qualitatively on strength of the fiber used. For example, if two fabrics of identical construction are woven, one from nylon and one from polyacrylonitrile (Orlon), the nylon fabric will be stronger than the polyacrylonitrile.

The box on p 117 discusses briefly the progress being made in developing a classical engineering technology which will permit the "engineering" of a textile of predetermined properties from fibers of known viscoelastic behavior. At present, however, this complex subject is best left to the textile engineer. From the practical standpoint there are a number of mechanical properties of textiles which are directly pertinent to the end user and for which there are standard tests available. These include breaking strength, elongation, tear strength and bursting strength. These, plus stiffness and energy absorption, will be considered below.

Breaking strength—The counter-

E. I. du Pont de Nemours & Co., Inc.

Fire hose *made of polyester fiber (Dacron) provides mechanical strength with light weight.*

Union Carbide Chemical Co.

Diaphragms *for railroad cars serve as seals and connections between cars. In this case acrylic fiber (Dynel) was used because of its excellent resistance to fire, water, detergents used in car maintenance, and weather.*

part of tensile strength for other engineering materials, breaking strength is a measure of the resistance to breaking in tension.

Standard ASTM tests are available for woven fabrics (D39), felts (D461) and nonwoven (bonded) fabrics (D1117). Tests describe grab, raveled-strip and cut-strip methods (referring to type of sample and clamp grip) in which fabric specimens of specified dimensions are broken in tension in both the warp and fill directions.

Results are reported in pounds warp and pounds fill for woven fabrics; pounds longitudinal and pounds crosswise for bonded fabrics; and pounds per 2-in. width for felts, which must be tested by the cut-strip method. (For felts, D461 also indicates a method of reporting tensile strength of felts in pounds per square inch by dividing lb-per-2-in. breaking strength by measured thickness of the felt in inches.)

Elongation — Unless otherwise specified, elongation (D39) is measured at any stated load and is obtained at the same time as breaking strength by means of a suitable autographic recording device. Results are reported as percent increase in length.

Bursting strength—This property is used primarily for knit goods (D231), felts (D461) and nonwoven fabrics (D1117). The machine used is either a constant-rate-of-traverse machine equipped with a bursting attachment, or an approved type of diaphragm bursting tester. Results are reported as average pressure in pounds per square inch required to burst 10 specimens.

Tearing strength—Three standard tearing strength tests are used to determine the resistance of a fabric to tear propagation:

1. Trapezoid method: Used for woven fabrics (D39) and nonwoven fabrics (D1117). An isosceles trapezoid of specified dimensions is marked on specimens of specified size. A cut is made in the center of the shortest side and perpendicular to it. The specimen is clamped in a tensile tester along the nonparallel sides of the trapezoid so that the cut is halfway between clamps, the short edge of the specimen held taut, the long edge lying in folds. Results are reported as average load in pounds warp and pounds fill. For nonwoven fabrics, "machine direction" and "cross-machine direction" are substituted for "warp" and "fill" respectively.

2. Tongue method: Used for woven fabrics (D39). A longitudinal cut is made in the center of the short side of 8 x 3-in. specimens. One tongue is inserted in each clamp of the tensile tester. Results are reported in pounds warp and pounds fill.

3. Elmendorf method: Used for woven fabrics (D1424). A rectangular specimen with a short cut is fastened between two clamps—one fixed and one on a sector-shaped pendulum. The pendulum is released, and specimen is torn as the pendulum moves away from the fixed clamp. The energy consumed in tearing the specimen is the difference in potential energy at the beginning and end of the swing. Results are reported as pounds to tear the specimen, and tearing energy per unit length in inch-pounds per inch of fabric. (Method used primarily for lightweight materials.)

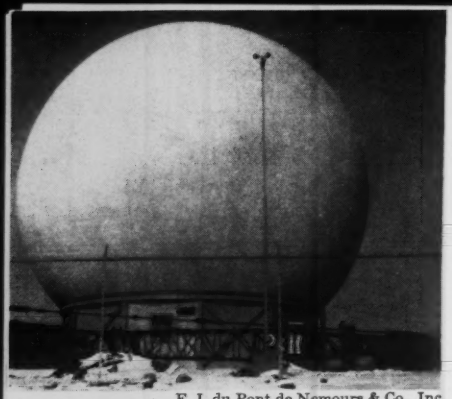
Splitting resistance—Used for felts (D461). A measure of the resistance to splitting of felts over 3/16 in. thick. A standard breaking strength tester is used. Specimens are split with a knife in the middle third of thickness for a distance of about 2 in. from end. One lip of the split felt is clamped in each clamp of the tester. Results are reported as average load in pounds required to split the specimens.

Energy absorption—Though there are no ASTM standard tests for measuring energy absorption of textiles, a brief discussion of some of the factors involved may be helpful.

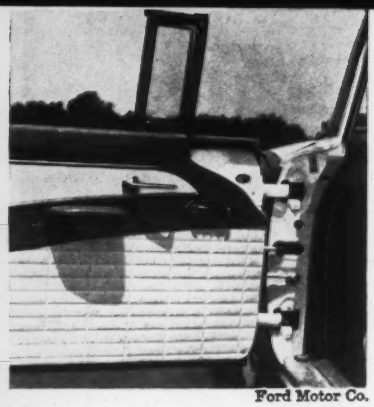
Textile fibers themselves have a certain "toughness" which can be expressed by the area under the stress-strain curve. Fig 1 shows typical stress-strain curves for various fibers. Note the outstandingly high energy absorption of nylon resulting from its combination of high tenacity and extensibility. Because the area under the curve is what counts, equal energy absorption characteristics may be obtained with a strong, low extensibility fiber, or a weak, high extensibility fiber.

A term commonly used in describing toughness of textile fibers is "work factor." This is defined as the ratio of the measured work of rupture to the product of load at break and extension at break (i.e., ratio of area under stress-strain curve to the area of the rectangle formed by the stress and strain axes and lines drawn parallel to these axes to the point of rupture).

In a textile form, energy absorption is usually associated with resil-



E. I. du Pont de Nemours & Co., Inc.



Ford Motor Co.

Troy Blanket Mills

Combination materials . . .

Air-supported structures, *such as this coated nylon fabric radome made by Birdair Structures, are economical and easily transportable.*

Backing *for vinyl upholstery and trim, made of bonded nonwoven fabrics, provides economical resilience and cushioning.*

Plastics reinforcements *consist of bonded nonwoven fabrics (in this case a 10 oz/sq yd Dacron fabric) as well as woven fabrics.*

ience, or the ability of a fabric to recover from deformation. Probably the most commonly measured energy absorption or resilience characteristic of textiles is compressional resilience.

The generally used method of determining compressional resilience is to select a given area of fabric and plot a force-penetration (or thickness) diagram as the material is progressively stressed over the selected area. Load is then progressively removed, and the resulting diagram recorded. If the sample is repeatedly loaded and unloaded, a series of curves result. The reductions in thickness after unloading, compared with original thickness, give an indication of the resilience of the material.

Stiffness—Stiffness or rigidity of a fabric is primarily important in the way it affects "hand" or "drape" (see section on tactile properties) and is dependent on both fiber and form.

Two standard test methods are described in D1388; D461 describes the tests as modified for felts. The two methods are:

1. Method A. Cantilever Test (preferred)—A strip of fabric is slid in a direction parallel to its long dimension so that its end projects from the edge of a horizontal surface. The length of overhang is measured when the tip of the specimen is depressed under its own weight to a point where a line joining the tip to the edge of the platform makes an angle of 41½ deg with the horizontal. One half of this length is the "bending length." Flexural rigidity, reported in inch-pounds (or milligram-centimeters), is calculated by multiplying the cube of the bending length times the weight per unit area of the fabric.

2. Method B. Heart Loop Test (alternate)—Recommended only for fabrics that tend to twist or curl. A strip of fabric is formed into a heart-shaped loop. Length of the loop is measured when hanging vertically under its own weight. From this length, bending length and flexural rigidity can be calculated. Results are reported in same manner as for Method A.

Abrasion resistance

Although strictly a mechanical property, abrasion resistance is such an extensive subject that it is covered separately here. "Abrasion" here is considered as destruction by rubbing away, as distinct from "wear." Wear is more commonly associated with all the conditions surrounding everyday service, of which abrasion is usually only one. Wear resistance is more commonly evaluated as a criterion for garment or other consumer fabrics.

Abrasion resistance of a fabric can be improved both by using the proper fiber and by using the proper textile form. For a given textile form, textiles will rank in abrasion resistance in the same order as the fibers from which they are made. Unfortunately, data on abrasion resistance of fibers are difficult to compare, as test conditions for reported values are not the same.

In general, nylon is recognized as having the best abrasion resistance of any textile fiber. Some of the other fibers in descending order of resistance are: cotton, wool, medium-high tenacity viscose rayon, cuprammonium rayon, normal tenacity viscose rayon, and acetate. Harder, less resilient fibers such as glass have very low abrasion resistance.

For some types of abrasive service, fabrics can be specifically designed for optimum resistance. For example, where in-service abrasion is to be primarily unidirectional, fabrics can be so woven that abrasion resistant surface fibers lie predominantly in the direction of anticipated abrading action (e.g., warp or fill-faced fabrics). In general smoother weaves provide superior abrasion resistance.

Standard tests—Because of the complex and variable nature of abrasion, a number of tests have been devised, each designed to simulate a certain type of abrading action. All are described in ASTM D1175:

1. Inflated diaphragm method (Stoll Abrader)—Determines resistance to abrasion of woven or knitted fabrics when abraded either unidirectionally or multidirectionally.

The specimen is stretched over an inflated diaphragm; abradant, which may be specified, is only rubbed back and forth (for unidirectional abrasion), or specimen may also be rotated (for multidirectional abrasion) until the end point of the test. The end point may be 1) complete abrading away until two electrical contacts on either side of the specimen make contact, or 2) a specified number of abrasion cycles.

Results are reported either as 1) number of cycles to destruction, or 2) effect of specified number of cycles on luster, color and fabric structure.

2. Flexing and abrasion method (Stoll Abrader)—Determines resistance to combination of flexing and

abrasion. The specimen is clamped over a folding bar or blade and subjected to flexing and abrasion by pulling back and forth with a reciprocal unidirectional motion over the bar or blade under known conditions of pressure and tension.

Results are reported as 1) number of cycles to rupture the specimen, 2) average percentage loss of breaking strength after abrasion for specified number of cycles, or 3) effect of flexing and abrasion on luster, color, napping, pilling, thickness, etc., at a given number of cycles.

3. Oscillatory cylinder method (Wyzenbeek Abrader)—Determines unidirectional abrasion resistance of fabrics in terms of an objective end point. Unless otherwise specified, specimens are abraded with No. 0 emery paper for 250 continuous reciprocating cycles. Results are reported as percentage loss in breaking strength or residual breaking strength of fabric after abrasion.

4. Rotary platform, double-head method (Taber Abrader)—Determines abrasion resistance of fabrics under rotary rubbing action, using controlled pressure and abrasive action. The specimen is rotated on a flat disk and abraded by two abrasive wheels (selected for the particular fabric) for a preselected number of revolutions. Results are reported as 1) percentage loss in breaking strength (determined by raveled strip method), 2) residual breaking strength, or 3) revolutions required to give specified destruction.

5. Uniform abrasion testing machine method (Shiefer Abrader)—Determines abrasion resistance of wide range of textiles under a variety of constant testing conditions. It can be used for woven or nonwoven fabrics, glass fabrics, yarns, threads and cloth. The specimen is clamped between parallel plate disks, one of which carries an abradant. The two disks rotate in contact in the same direction at the same speed but on two noncoaxial axes.

Results are reported as a comparison of characteristics before and after abrasion. The characteristic to be measured (e.g., thickness, electrical capacitance, absorption of beta emission from a radioactive source, etc.) is determined by the tester or by the particular fabric specification. Measured values are plotted against number of rotating cycles, and abrasion curves are drawn. In some cases, the number of rotations to the destructive end point of test may give adequate evaluation (the logarithm to the base ten of the number of rotations has been found to be more representative of relative abrasion resistance than the actual number of rotations).

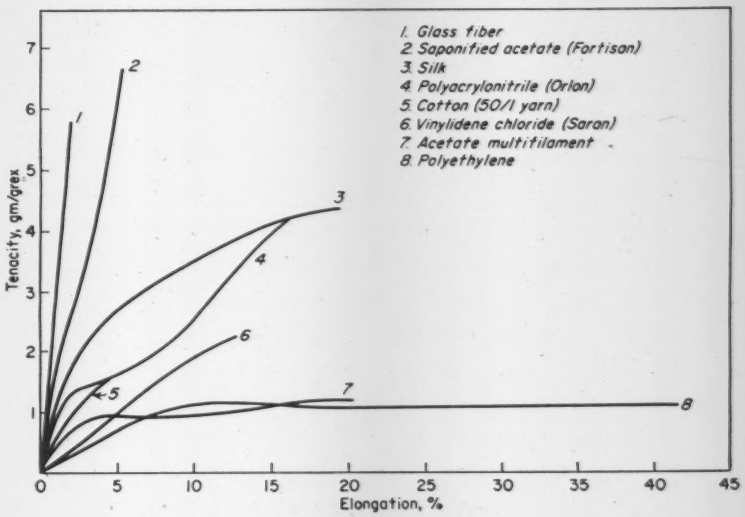


Fig 1 — *Typical stress-strain curves for various fibers.* (Harris)

Thermal transmission

Heat is transmitted through textiles by convection, radiation and conduction. The relative thermal conductivity of the fibers used in a textile usually has little effect on overall thermal transmission characteristics.

Essentially thermal transmission of a textile is dependent on the amount and configuration of air spaces within the textile; thus at a given air permeability value, it is primarily a function of textile thickness. Physical characteristics of fibers are important in that certain fibers tend to form bulkier yarns and bulkier fabrics, e.g., wool yarns are generally bulkier than silk and thus tend to form thicker fabrics for a given amount of yarn.

From the standpoint of service requirements, an important consideration in maintaining thermal insulating values in a given textile is the textile's ability to maintain a given thickness in service. This ability is a function of the resilience of the fabric, primarily related (in an extremely complex way) to the resilience or elastic behavior of the fiber. Compressional resistance can be used as one measure of such ability in a fabric (see earlier section on mechanical properties).

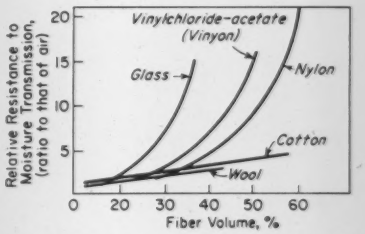


Fig 2 — *Effect of hydrophobic versus hydrophilic fiber content on moisture permeability of textiles.* (Kaswell)

Standard tests — Thermal transmittance by the guarded hot-plate method (D1518) determines overall thermal transmission coefficients due to conduction, convection and radiation through textile fabrics and batting.

The specimen is spread flat on a hot plate (finished side up) covering both plate and a guard ring within a controlled atmosphere chamber. The plate is brought to operating temperature, and measurements made 30 min after plate and specimen have reached equilibrium. The test is repeated with the hot plate uncovered.

Results are calculated as follows:

1. The combined transmittance coefficient of specimen and air in Btu/hr/sq ft/°F is equal to the power loss from the test plate, in Btu per hr, divided by the area of

the plate, in sq ft, and the temperature difference between the test plate and the air, in °F.

2. The transmittance coefficient of the bare plate is calculated in the same way.

3. Intrinsic transmittance coefficient, U_2 (corresponding to "C", as defined and used by ASTM, American Society of Heating and Air-Conditioning Engineers, and American Society of Refrigerating Engineers), is equal to the product of the two coefficients (1 and 2 above) divided by their difference.

4. Specific conductivity coefficient, k, is equal to the product of U_2 and fabric thickness in inches.

5. Conductivity coefficient, K, is equal to the product of U_2 and fabric thickness in feet.

6. Intrinsic thermal *resistance* coefficient is the reciprocal of the conductivity coefficient. Intrinsic thermal resistance in clos is $1.137/U_2$; specific thermal resistance in clos is 1.137/k.

Air or gas permeability

Permeability is a function of fiber diameter and textile form. Of these, form is probably by far the most important. Essentially air permeability is controlled by the amount and configuration of air spaces within the textile.

In woven fabrics permeability is thus determined by number of picks per inch (increasing pickage decreases permeability), weight of the yarn (lighter weight yarns increase permeability), amount of twist in a yarn (increasing twist increases permeability), and overall thickness of the fabric.

In felts, permeability is affected primarily by fiber diameter and density of the fabric. In bonded nonwoven fabrics, the additional effect of binder content must also be considered.

For filtration applications, shape of fiber cross section can have a considerable effect on particle retention. Studies have determined that fibers of a bone-shaped cross section generally show good retention of finer particles.

Standard tests—There are two standard methods of determining air or gas permeability:

1. NBS Air Permeometer (D-737)—The specimen is clamped over an orifice of known size; air is drawn by suction fan through the sample and orifice; and rate is measured. Results are reported as cubic feet of air per minute per square foot of fabric at a stated pressure drop.

2. Gurley Densometer—The device consists of two coaxial circular plates with an orifice in the center of each. Air is forced hydraulically through the specimen clamped between the plates. Results are reported as number of seconds required for a specified volume of air to pass through the fabric.

Liquid permeability

Many of the factors affecting air permeability of fabrics hold true for liquid permeability. An additional factor in liquid permeability is the nature of the fiber. Hydrophobic fibers, such as glass, vinyls or acrylics, do not affect permeability. However, when hydrophilic fibers, such as cotton or wool, are used, the moisture transmission through the fiber must also be considered.

Fig 2 shows the general effect of fiber on permeability. As hydrophobic fiber volume of the textile increases, resistance to moisture transmission increases rapidly, indicating the dependence of moisture transmission in such fabrics on air spaces. As hydrophilic fiber volume increases, resistance increases only slightly, indicating that moisture is being transmitted through the fiber, as well as through the air spaces.

Standard tests—There are no standard ASTM tests for determining liquid permeability of textiles. Proprietary tests have been devised by individual organizations, which commonly report permeability in terms similar to that of air permeability, i.e., volume of liquid per minute per square unit of fabric at a stated pressure head or pressure differential.

Electrical properties

In virtually every electrical application of textiles, the fabric or fiber is used in combination with another material, such as varnish, a plastics resin or an elastomer. In such applications, the textile acts primarily as a reinforcing material, the dielectric characteristics being provided by the coating or resin. Consequently, the properties important in a textile for electrical applications are primarily strength and durability, as well as compatibility with the coating material or impregnant.

Tactile properties

Tactile or sensory characteristics of textiles are primarily important in garment or consumer fabrics. However, a brief discussion here may be pertinent.

Tactile properties are subjective, and must be described more or less qualitatively. There are, however, certain quantitative measures available. The major tactile characteristics are hand (handle), drape and luster.

Hand is defined as the feel of the material. It is dependent on a complex combination of properties of both the fiber and the textile form. These properties include stiffness, hardness and resilience. (See section on mechanical properties for discussion of stiffness and resilience.) Table 3 lists physical properties con-

TABLE 3—TERMS RELATING TO HAND OF FABRICS

Physical Property (component of hand)	Description	Terms Used in Describing Range of Property
Flexibility	Ease of bending	Pliable (high) to stiff (low)
Compressibility	Ease of squeezing	Soft (high) to hard (low)
Extensibility	Ease of stretching	Stretchy (high) to nonstretchy (low)
Resilience	Ability to recover from deformation. Resilience may be flexural, compressional, extensional, or torsional	Springy (high) to limp (low)
Density	Weight per unit volume (based on measurement of thickness, fabric weight[a])	Compact (high) to open (low)
Surface Contour	Divergence of the surface from planeness	Rough (high) to smooth (low)
Surface Friction	Resistance to slipping offered by the surface	Harsh (high) to slippery (low)
Thermal Character	Apparent difference in temperature of the fabric and the skin of the observer touching it	Cool (high) to warm (low)

[a]Thickness and weight measurements are made in accordance with the procedures described in the ASTM methods for specific fabrics.
Source: ASTM Standards, Part 10, '58, p 59.

What the Words Mean—A Glossary of Textiles

Acetate—Synthetic fibers or filaments made from cellulose acetate.

Acrylic fiber—Synthetic fiber prepared mainly from acrylonitrile.

Avisco—Trademark for viscose rayon (American Viscose Corp.).

Braid—Narrow tubular or flat fabric produced by intertwining a single set of yarns.

Breaking length—Alternate term for *tenacity*. The length of a specimen whose weight is equal to the breaking load.

Cabled yarn or cord—Yarn produced by twisting together two or more plied yarns.

Canvas—A heavy, firm, plain-weave cotton fabric, or a lightweight duck.

Clo—The amount of thermal insulation necessary to maintain a sitting-resting person in comfort in a normally ventilated room (air movement 20 fpm, 70 F, less than 50% RH). For value of clo, see Thermal Transmittance in text.

Compliance—In fibers, elongation produced by any load. Inverse of stiffness; considered to affect the "feel" of fabrics.

Compressibility—A term related to the hand of fabrics. Refers to resistance of the fabric to squeezing: ranges from soft (high) to hard (low). Objectively tested by measuring fabric thickness at various pressures.

Count—The number of warp yarns (ends) or filling yarns (picks) per inch.

Cover factor—Fraction of fabric surface area covered by yarns (assuming yarn to be round). Indicative of compactness of weave. Conventionally designated *K*, it is equal to the members of threads per inch divided by the square root of the yarn number (cotton system). For cotton fabrics, K varies from 5 for cheesecloth to 27 for fine poplins. Knit cotton goods usually average about 0.8.

Crimp—1) Textile fibers are considered to be crimped in the weave when they are wavy with the distance between the peaks being relatively short, e.g., ¼ in. or less. 2) The difference in distance between two points of a fiber or yarn as it lies in the weave in an unstretched condition and the same two points when the fiber or yarn is unravelled from the fabric and straightened. Expressed as % of unstretched yarn length.

Denier—Weight in grams of 9000 meters of yarn (see *yarn number*).

Density—For textiles, a term related to the hand of fabrics. Weight per unit volume based on thickness and fabric weight. It ranges from compact (high) to open (low).

End—1) An individual sliver, roving, yarn or cord. 2) In fabrics, an individual warp yarn (single or ply) or cord.

Fiber—A unit of matter having a length at least 100 times its diameter or width, and, except for glass, having a definitely preferred orientation of its crystal unit cells with respect to a specific axis. Requisites for spinning fibers into yarns include a length of at least 5 mm, and sufficient strength, pliability and cohesiveness.

Fiber K—Trademark for experimental elastomeric fiber on which no data are available (E. I. du Pont de Nemours & Co. Inc.).

Filament—A silk or synthetic fiber characterized by extreme length. Length permits its use in yarn without, or with very little, twist.

Filling—Yarn running the width of a fabric, at right angles to the *warp* yarns (pick).

Float—In a woven fabric, the portion of a warp or filling yarn that extends unbound over one or more filling or warp yarns.

Flock—Very short (less than ¼-in.) fibers, usually cotton, rayon or wool. Often applied as a finish to other materials by spraying against an adhesive.

Flush or face—In weaving, to flush is to float over several yarns without intersecting, leaving that particular yarn to predominate on the surface of the fabric. For example, warp-flush twill is a twill fabric with the warp yarns predominating on the face.

Gray goods—Woven or knitted fabrics which have had no finishing treatment.

Grex—A yarn number; weight in grams of 10,000 meters of yarn.

Hand—See text: Tactile Properties.

Hank—A unit of length used in determining *yarn number*.

Lea—1) A unit of length (300 yd) used to determine the number of linen threads. 2) A skein used for strength tests, usually containing 80 threads and a total length of 120 yd.

Lofty—Term applied to wool or other fibers or yarns which are open, lively and highly elastic.

Moisture regain—Moisture content of a textile, expressed as percentage of its oven-dry weight.

Monofilament—A filament large enough to be used by itself as a yarn (usually greater than 15 denier).

Multifilament—Yarn made from filaments.

Pe-Ce fiber—Trademark of German synthetic fiber based on polyvinyl chloride.

Perlon L, T and U—German trademarks for synthetic fibers: Perlon L is a type 6 nylon; Perlon T is a type 66 nylon; Perlon U is a polyurethane.

Pick—An individual *filling* yarn.

Plied or ply yarn—A thread composed of two or more single yarns twisted once together.

Rayon—Generic term for synthetic textile fibers and filaments composed of regenerated cellulose.

Reevon—Trademark for polyolefin fibers (Reeves Bros., Inc.).

Roving—A loose assemblage of fibers drawn or rubbed into a single strand, with very little twist. Intermediate stage between *sliver* and *yarn*.

Royalene—Trademark for polyethylene and polypropylene fibers (U. S. Rubber Co.).

Saran—Formerly a trademark (Dow Chemical Co.), now a generic term for synthetic fibers composed of vinylidene chloride and vinyl chloride copolymer.

Single yarn—Often called "singles." An aggregate of twisted fibers or filaments. Two or more single yarns, when twisted together, form a *ply yarn*.

Sizing—Any of a number of compounds that when applied to fibers or yarns form a more or less continuous film around the fiber or yarn. May be applied to assist processing or alter properties of fabrics.

Skein—A continuous strand of yarn or cord of any desired length, in the form of a collapsible coil. Obtained by winding a definite number of turns on a reel under prescribed conditions.

Sliver—A continuous strand of loosely assembled fibers

continued on p 130

Continued

that is approximately uniform in cross-sectional area and without twist.

Staple—A term denoting the average length of any species of fiber.

Tenacity—Ultimate tensile strength of a yarn, expressed in gm per denier. Tenacity can be converted to tensile strength in psi by multiplying by 12,800 times the specific gravity.

Terylene—British trade mark for polyethylene-terephthalate-type polyester fiber (Imperial Chemical Industries, Ltd.).

Toughness—The ability of a fiber to endure large, permanent deformations without rupture. "Toughness index" is also used; it is defined as one-half the product of load and elongation, the premise being that such a triangle is a good approximation of the true area under a stress-strain curve.

Tow—In synthetic fibers, a multifilament strand suitable for cutting into staple and for spinning into spun yarn.

Twist—The turns about their axes of fibers, yarns or cords. Usually expressed in turns per unit of length. Twist is referred to as "S" or "Z", i.e., a yarn or cord has "S" twist if, when held in a vertical position, the spirals conform in direction of slope to the central portion of the letter "S", and "Z" twist if the spirals conform in direction of slope to the central portion of the letter "Z".

Typp—Unit of yarn number: number of thousands of yards per pound avoirdupois.

Velon—Trademark for a vinylidene chloride-vinyl chloride copolymer (saran) fiber (Firestone Plastics Co.).

Vinyon N—Trademark for filament form of Dynel (Union Carbide Chemical Co.).

Warp—Yarns running lengthwise in a woven fabric.

Warp face—Weaves in which the face is formed primarily by the warp.

Yarn—Generic term for an assemblage of fibers or filaments twisted or laid together to form a continuous strand suitable for weaving, knitting, etc., into textiles.

Yarn construction—Term used to indicate the *yarn number* of the single yarn (20s, 40s, etc.) and the number of strands combined to form ply yarn or card.

Yarn number—Often inaccurately called yarn count or size. Relative measure of fineness or dimension, as determined by various yarn numbering systems used with different types of yarn (all references to pounds are in avoirdupois):

Asbestos glass (cut)—The number of 100-yd lengths per lb.

Cotton, spun silk (hank)—The number of 840-yd hanks per lb.

Jute (spyndle)—The weight of a 14,400-yd spyndle of yarn, expressed as lb per spyndle.

Linen (hank or lea)—The number of 300-yd hanks or leas contained in 1 lb.

Rayon, spun and woolens or worsted (typp)—Number of thousands of yards per lb.

Woolen (cut)—Number of 300-yd cuts or hanks per lb.

Worsted (hank)—Number of 500-yd hanks per lb.

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tributing to hand, and the terms used to describe them quantitatively. Since hand is subjective, there is no standard test for measuring it.

Drape, though difficult to separate from hand, refers more specifically to the effect of the weight of the material in influencing deformation of the fabric. Two devices most commonly used to measure drape are the MIT Drap-o-meter and the FRL (Fabrics Research Laboratories) Drapemeter.

Luster is the gloss or sheen of a fabric caused, primarily, by light reflectance from the fibers of the fabric. The overall luster of a fabric can be altered or controlled to a great extent by changing the orientation of fibers and yarns within the fabric.

Luster can be measured by one or more of three methods: 1) objective determination of the amount of light specularly reflected from the fabric, 2) subjective methods, which measure the contrast between specular and diffuse reflection, and 3) goniophotometric methods, which develop a family of curves which rather completely describe light reflectance of the surface from all angles.

Acknowledgments

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Chemstrand Corp.
Chicopee Mills, Inc.
Dow Chemical Co.
E. I. du Pont de Nemours & Co., Inc.
Fabric Research Laboratories, Inc.
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Lowell Institute of Technology
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Reeves Bros., Inc.
Russell Mfg. Co.
Tennessee Eastman Co., Div. of Eastman Kodak Co.
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Union Carbide Chemical Co., Div. of Union Carbide Corp.
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Dow Corning

SILICONE NEWS

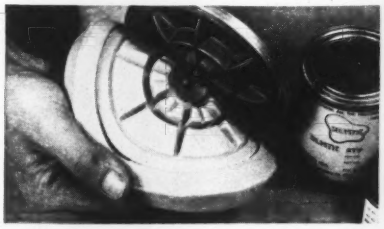
for design and development engineers • No. 64

NEW DESIGN TOOL FEATURED IN MOVIE

How designers use Silastic® RTV as a valuable tool is depicted in a fast-moving, 14 minute color-sound movie.

Design engineers in all fields put to practical advantage the unique properties of this silicone rubber that vulcanizes at room temperature.

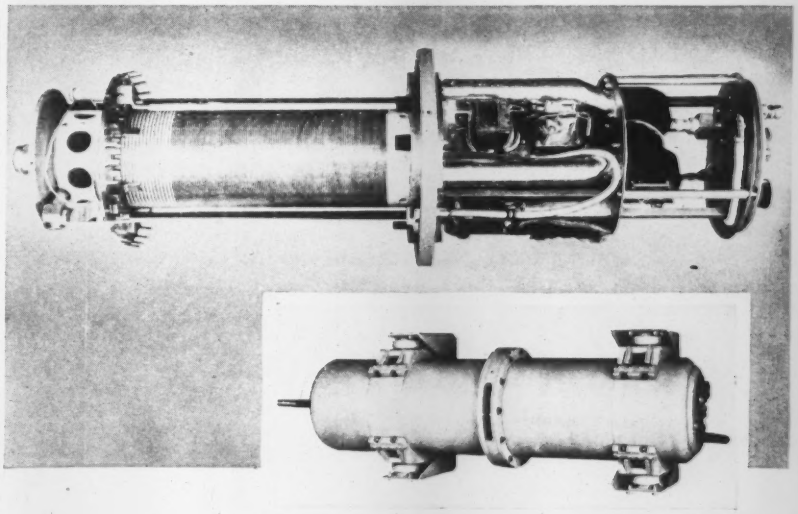
For example, flexible molds with the finest of detail are easily produced. In turn, parts of low melting alloys and plastics, such as epoxy resins, are produced by simply pouring the molten material directly into



the mold. Temperatures up to 500 F do not affect the mold. Release is easy, quick.

One-of-a-kind rubber parts and prototype duplicates are also made easily and quickly of Silastic RTV. This unique product flows around even the most intricate shape, forms a custom built rubber part with minimum effort, and eliminates costly delays and the need for special molds.

In potting or encapsulating electronic units, Silastic RTV has proved to be an ideal medium. It provides the desired protection against shock, vibration, moisture and dirt. Because no heat is required to vulcanize the rubber, there is (Cont. pg. 2)



HOW TO HOLD DOWN HIGH FREQUENCY POWER LOSSES

When designing equipment for top performance and efficiency, losses must be held to the absolute minimum. That's why silicone-glass laminate was specified for coil forms in these antenna tuners designed for military radio transmitting sets.

Developed for the U. S. Navy by ITT Laboratories to provide high frequency band transmission of voice, facsimile and telegraph signals, this antenna tuner is one of the major building block components used in the installation of various models of radio transmitting equipments.

With a maximum power capacity of 500 watts, the antenna tuner is used in conjunction with such model transmitters as the AN/SRT-14. Another, the AN/SRT-15, may transmit an RF carrier of either a 100-watt or a 500-watt nominal level while the third, the AN/SRT-16, is capable of transmitting two carriers simultaneously.

Used in all three sets, the antenna tuner provides the means for resonating and matching the transmitter to its antenna. The RF (radio frequency) portion of the tuner consists of a main coil, a coupling coil and an electrically operated RF switch.

Wound on a 5.62 inch diameter cylinder of silicone bonded glass laminate, the .064″ diameter silver wire of the main coil spans 16″ of the coil form's length.

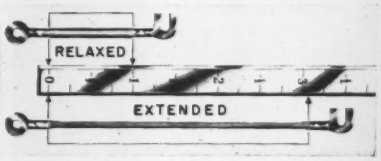
Glass cloth bonded with Dow Corning silicone resin was chosen for the main coil form after comprehensive tests confirmed this material would assure low losses at high frequency operating levels.

Strong and lightweight, silicone bonded glass laminates maintain optimum dielectric properties and high mechanical strength even at temperatures of 250 C. They also provide low water absorption plus superior resistance to arcing, corona, and corrosive atmosphere. **No. 652**

NEW S-T-R-E-T-C-H WIRE

A new type of wire offers extended utility — because it's stretchable. Manufactured by Stretch Wire Corporation, New Rochelle, New York, the wire is available insulated with Silastic®, the Dow Corning silicone rubber, for superior performance under extremely adverse operating conditions.

Designed for use on requirements of 50 watts or less in appliances, portable tools, communication systems, aircraft and missiles, as well as special military underwater applications, Stretch Wire has an extension factor of 165% or more and return.

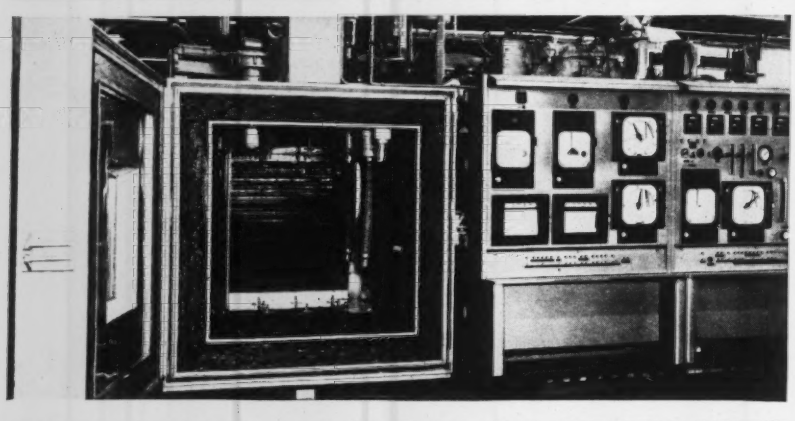


In missile and ordnance work, Stretch Wire has been proved to work effectively at high velocity launchings at speeds of 1000 feet per second and to withstand inertia loads of 800 G's.

Stretch Wire engineers chose Silastic because of its highly desirable (Cont. pg. 2)

FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE



PREVENT VAPOR BLOWOUTS

Fluids in closed systems subjected to temperature extremes can cause problems—require special designs to withstand vaporization pressures. How best to cope with this high pressure hazard? Eliminate it by using a silicone fluid—according to Tenney Engineering, Inc., Union, New Jersey.

Tenney builds environmental test chambers used in testing electronic gear and guidance packages for aircraft and missiles. These chambers are required to produce test temperature conditions that range from as low as —170 F to a high of 1200 F.

These high and low temperature service requirements created serious problems. Most heat transfer fluids evaluated were not practical for temperatures as low as —90 F. Those that were suitable at low temperatures developed high vapor pressures at elevated temperatures. This meant designing the unit to withstand high pressures . . . eliminate chances of blowouts and possible fire hazards.

Tenney engineers, however, made their test chambers far safer and virtually trouble-free by selecting 2 centistoke Dow Corning 200 Fluid as the heat transfer medium. This nonoxidizing, nongumming and noncorrosive silicone fluid builds up only negligible vapor pressure. Over the chamber's operating temperature span, vapor pressures of this silicone fluid never exceed 50 psi, virtually eliminating the possibility of leakage. No organic fluid compares in performance.

Besides eliminating a fire hazard, Tenney engineers were able to keep the design simple by using 200 Fluid. In addition, the silicone fluid makes possible the use of one control system for both high and low temperature testing. *No. 653*

STRETCH WIRE *(Continued)*

combination of properties. Its brittle point is lower than —150 F and still it is serviceable at 500 F and higher. Silastic is highly resistant to heat, oxidation and chemical attack, and its water absorption is low. Electric strength remains constant over a wide operating temperature range.

The desirable combination of properties of Silastic that help make Stretch Wire practical for a wide variety of applications makes it valuable in solving other diverse design problems. *No. 654*

SILASTIC RTV *(Continued)*

no adverse effect on delicate, sensitive components.

Calking and sealing where extreme temperatures are encountered is still another area where Silastic RTV has proved to be very practical. It conforms to the required shape, stays flexible and serviceable from —70 to 500 F.

To make arrangements for a free showing in your plant of this movie about a product with uses limited only by one's imagination, circle . . . . . *No. 655*

new literature and technical data on silicones

When you consider all the properties of a silicone rubber, you'll specify Silastic. When fuel, oil, solvent and chemical resistance are special requirements, you'll want to refer to a new data sheet that describes the effect of various acids, bases, solvents and oils on Silastic. This valuable designer's reference will aid in selecting the best type of silicone rubber to meet your requirements. *No. 656*

Do you know that Class H insulated transformers offer smaller size and lighter weight, plus better performance and lower maintenance costs? A recent article cites the role silicone insulation plays in making such savings possible. *No. 657*

You say, they save — You can provide up to 100% longer surface protection if you specify silicone-based paints for the domestic appliances and the industrial equipment you design. Examples of design-customer savings are illustrated in a new, 4-page brochure. A unique, full page graph will help you choose the type of paint best suited for every application, and a separate listing of producers of silicone paints is also included to assist you in obtaining the protective coating you seek. *No. 658*

The big picture—A cross-section of silicone products and their diversified applications is compiled in the illustrated Reference Guide to Dow Corning Silicones. Over 200 products, for domestic and industrial applications, can be reviewed at a glance. Brief but descriptive explanations offer the information you'll want to use in considering Dow Corning Silicones to help solve your design problems. *No. 659*

Electronics exposed — A new silicone dielectric readily flows around electronic parts and subassemblies, then gels to a transparent, protective cushion. Its use avoids stress difficulties common to rigid potting materials, eliminates problems of sealing liquid dielectrics, allows visual inspection, and even permits test probing because it reseals itself. *No. 660*

Dow Corning Corporation, Dept. 7019, Midland, Michigan

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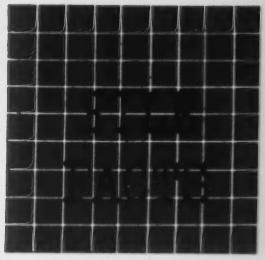


Dielectric Strength of Nonmetallics

v/mil

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Mica	1500	500	Nylons	443	57	Melamines, GP	320	10
Polymethylstyrene	1420	530	Mica, Glass-Bonded	435	165	Phenolics, GP & Shock Res	313	113
Polyvinyl Chloride, Rigid	1063	337	Ethyl Cellulose	425	75	ABS Resins, Extra-High Impact	312	—
Polypropylene	795	25	Allyl (cast)	415	85	Polyester, Nonrigid	310	90
Methylstyrene-Acrylonitrile	610	—	Polyvinyl Butyral, Polycarbonate & Chlorinated Polyether	400	—	Cellulose Acetate	308	58
CFE Fluorocarbons	565	35	Melamines, Electrical	390	40	Melamines, Glass Fiber-Filled	275	25
Nylon, Glass Fiber-Filled	504	16	Diallyl Phthalate, Glass Fiber-Filled	388	42	Phenolics, Rubber	263	13
Modified Polystyrenes	480	170	ABS Resins, Med-High Impact	378	38	Polyvinyl Chloride, Nonrigid	262	238
Acetal	500	—	Phenolics (cast)	375	75	Melamines, Shock Res.	250	120
Polyethylenes	480	—	Cellulose Propionate	375	75	Alumina Ceramics	250	50
Acrylics (cast)	475	25	Diallyl Phthalate, Asbestos-Filled	354	24	Phenolics, Chem Res	250	25
Hard Rubber	472	128	Ureas	350	50	Forsterite	250	—
Polystyrene	470	30	Phenolics, High Freq	338	38	Phenolics, Heat Res	225	125
Polyester, Rigid	455	115	Plastics Laminates, High Pressure	335	265	Steatite	213	67
Plastics Laminates, Low Pressure	450	350	Silicones & Cellulose Acetate Butyrate	325	75	Cordierite	185	45
Cellulose Nitrate	450	150	Alkyds	325	25	Standard Electrical Ceramics	178	122
Polyvinyl Formal	450	150				Zircon	175	115
Epoxies	450	100				Phenolics (cast), Transp.	163	87
TFE Fluorocarbons	450	50						
Epoxy (cast) & Acrylics	450	50						

[a] Short-time.

Dielectric Constant of Nonmetallics[a]

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Alumina Ceramics	8.9	0.7	Phenolics, Rubber	5	—	Ethyl Cellulose	3.2	0.4
Mica, Glass-Bonded	8.25	1.25	Polyester, Nonrigid	4.9	1.2	Polyvinyl Formal	3	—
Lead Silicate Glass	8.1	1.5	Phenolics (cast), Mech, Chem & High Freq	4.75	0.75	Polycarbonate	2.96	—
Phenolics (cast), GP	8	3	Cellulose Acetate Butyrate	4.7	1.5	Acrylics (cast)	2.95	0.25
Soda-Lime Glass	7.3	0.1	Borosilicate Glass	4.6	0.6	Methylstyrene-Acrylonitrile & Chlorinated Polyether	2.81	—
Zircon	7.25	1.95	Polysulfide-Epoxy (cast)	4.5	1.5	Modified Polystyrenes, Med-High Impact	2.8	0.3
Mica, Muscovite	7.05	1.65	Plastics Laminates, Low Pressure	4.5	1.1	Modified Polystyrenes, Extra High Impact	2.6	0.7
Melamines, Glass Fiber-Filled	7.05	0.15	Alkyds	4.5	0.5	Urethane Flexible Foam	2.55	0.35
Polyvinyl Chloride, Nonrigid	7	1	Silicones	4.35	0.75	Acrylics	2.5	0.5
Ureas	6.65	0.25	Boron Nitride	4.15	—	Polyvinyl Chloride, Rigid	2.5	0.2
Melamines, Shock Res	6.5	0.4	Allyl (cast)	4.05	0.75	Polymethylstyrene	2.48	—
Mica, Fluor-Phlogopite	6.5	—	Epoxy, Foamed-in-Place	4	2	Polystyrene	2.46	0.26
Phenolics, Heat Res	6.4	1.6	Vinylidene Chloride	4	1	CFE Fluorocarbons	2.34	0.04
Cellulose Nitrate	6.4	—	Diallyl Phthalate	4.0	0.7	Polyethylenes	2.3	—
Forsterite	6.35	0.15	Nylons	3.95	0.55	Polypropylene	2.05	0.05
Aluminum Silicate Glass	6.3	—	Hard Rubber	3.85	0.95	TFE Fluorocarbons	2.0	—
Phenolics, Chem Res	6.25	0.75	Silica Glass	3.8	—	Polyethylene Flexible Foam	1.49	—
Standard Electrical Ceramics	6.2	0.8	ABS Resins, Extra High Impact	3.78	—	Prefoamed Epoxy	1.47	0.43
Polycrystalline Glass	6.18	0.60	Epoxy (cast) & Acetal	3.6	0.1	Prefoamed Silicone	1.26	—
Steatite	6.0	0.5	Cellulose Propionate	3.5	0.1	Urethane Rubber & Silicone Foamed-in-Place	1.23	0.17
Melamines, GP	5.7	0.1	ABS Resins, Med-High Impact	3.45	0.65	Prefoamed Cellulose Acetate	1.11	0.01
Phenolics, GP & Shock Res	5.5	1.5	Nylon, Glass Fiber-Filled	3.41	0.04	Prefoamed & Foamed-in-Place Polystyrene	1.06	0.01
Cordierite	5.16	1.08	Polyester, Rigid	3.4	0.6			
Cellulose Acetate	5.1	1.9	Polyvinyl Butyral	3.33	—			
Plastics Laminates, High Pressure	5.1	1.7						

[a] At 10^6 cycles.

For more information, circle No. 485

MEET MRS. PETER PEFF

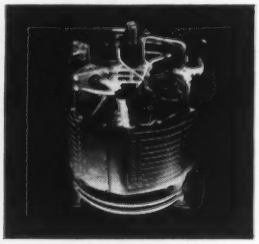
...and her company's new lightweight liquid-oxygen "vacuum bottle" for jet planes

Mrs. Peff, president, Superior Air Products, Newark, N. J., with Supairco's recently developed liquid-oxygen "vacuum bottle."

MANY a tough problem has been solved by Mrs. Peff and her company since 1952, when she assumed the presidency after her husband's death. Specialists in building low-temperature apparatus and complete plants to produce oxygen and other gases, "Supairco" was asked recently to develop a light, compact container to supply oxygen for aircraft crews at high altitudes.

Ingenious design utilizing the broad and varied properties available in copper and its alloys produced the "vacuum bottle" shown above. The inner sphere is of Everdur®, Anaconda copper-silicon alloy, which has the workability and resistance to corrosion needed —and, more important, the strength and toughness to make possible a relatively thin, light shell that can withstand vibration and fatigue stresses aloft—plus shocks from catapult launchings and carrier landings. The outer shell is of Anaconda copper, highly polished to reflect heat. This, plus a vacuum under .001 microns between the spheres, holds liquid oxygen at —297 F.

Starting with over 100 standard copper alloys, Anaconda can provide an almost unlimited number of combinations of useful properties. When new and unusual problems arise, use Anaconda technical specialists to help you select metals for your needs. Address the American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. 5941



LEFT: Inside the copper shell in main illustration is this slightly smaller liquid-oxygen container made of Everdur, the metal that spins and machines readily, is easy to join by soldering, brazing, welding. **RIGHT:** Completed liquid-oxygen converter, built by Mine Safety Appliances Company, Pittsburgh, Pa., serves 8-man crew. It is one-third the weight of the cylinder it replaces, takes much less space.

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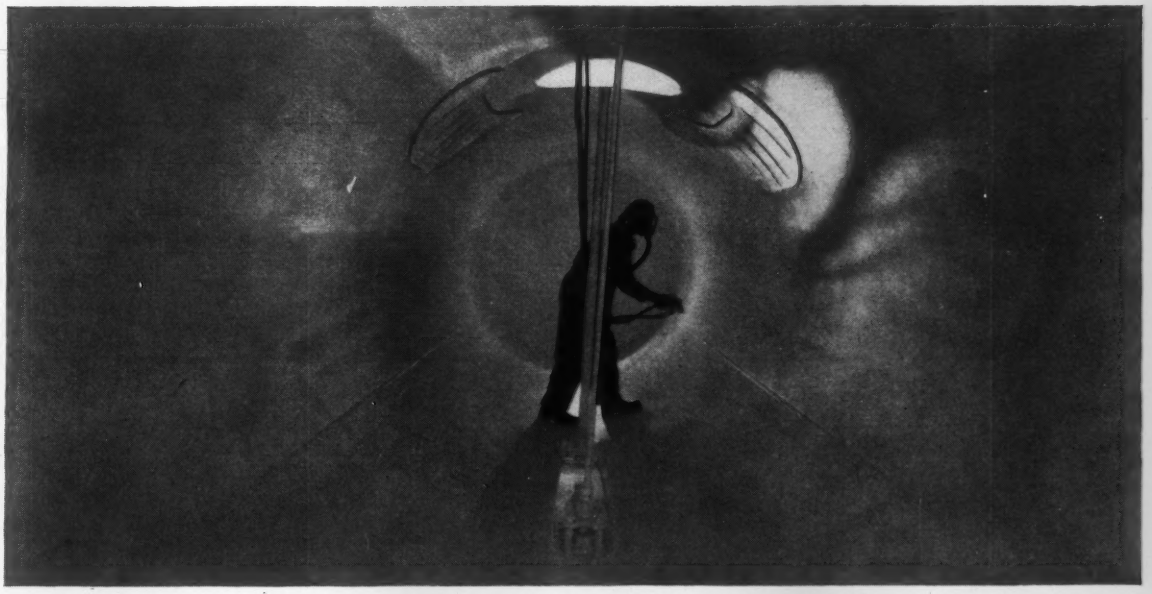


Spraying *inside of tank car with new high density polyethylene dispersion coating.*

High Density Polyethylene Coating Can Be Sprayed

■ A sprayable Type III (higher density) polyethylene coating, said to be the first such coating ever developed, is now available in semi-commercial quantities from Koppers Co., Inc., Plastics Div., Koppers Bldg., Pittsburgh 19. The coating is called Super Dylan.

The coating is made by dispersing finely divided Type III polyethylene powder in water or solvents to form semi-stable dispersions. The dispersions are applied at room temperature to hot or cold targets with conventional spray equipment. The sprayed object is then baked in an oven to fuse the polyethylene to itself and to the substrate. A bake cycle of 15 min at 400 F is recommended for sheet metal and a cycle of 15 min at 450 F is considered best for thick-walled pipe.

The resulting high density polyethylene coating is adherent, flexible and continuous. It has good resistance to impact, separation and chemical attack. Both water and solvent-base coatings have successfully been applied to cold and hot rolled steels, stainless steel, aluminum and copper.

Properties and uses

The new material is expected to find use as a coating and lining material on industrial process equipment, tanks, drums, pipes, automotive parts, appliances, marine equipment and cans. It is also expected to find use as an electrical insulation. An ice cube tray coated with the dispersion coating released the ice cubes rapidly and cleanly after the water had been frozen 16 hr at 0 F. An industrial wash kettle cover, agitator and baffle performed well for over a year in an atmosphere of hydrochloric acid and methanol; the previously used coating failed in

This article is based on a paper by S. E. Hmiel and H. G. Guy presented at a recent meeting of the Pittsburgh section of the Society of Plastics Engineers.

less than 3 months in this corrosive atmosphere.

Laboratory and field tests show the coating has good resistance to weathering, salt spray and chemicals.

Water resistance—The polyethylene coating adhered well to a metal specimen after 5 hr immersion in water at 160 F. However, the coating embrittled after prolonged exposure at this temperature.

Heat resistance—The surface of polyethylene-coated specimens did not peel or rupture after dry heat aging 72 hr at 160 F.

Chemical resistance—Polyethylene-coated cold rolled sheet steel was exposed to liquid, vapor and liquid-vapor phases of various chemicals and solvents. The coating had good resistance to most chemicals and solvents with the exception of glacial acetic acid and hydrochloric acid which permeated the coating and attacked the metal substrate.

PROPERTIES OF HIGH DENSITY POLYETHYLENE COATINGS

Type →	Solvent-Base	Water-Base
LIQUID COATING		
Solids Content, %	40-45	35-40
Weight, lb/gal	7.2	8.0
Viscosity, cs	Medium-Heavy	Medium-Heavy
Storage Stability, mo.	3-6	3-6
DRIED COATING		
Continuity	No pinholes	No pinholes
Flexibility[a]	Good	Good
Abrasion Res[b]	Good	Good

[a]Tested by bending a coated specimen over a ⅛-in. mandrel.
[b]Taber H-22 wheel.

Weather resistance—The high density polyethylene coating was unchanged after 1200 hr exposure to ultraviolet light in an Atlas Fadeometer.

Salt spray resistance — Pipes coated with the dispersion coating withstood 600 hr salt spray without any sign of corrosion.

Coatings vs Chemicals

These chemicals and fluids do not affect Super Dylan water and solvent-base polyethylene coatings at room temperature (aged 3 months):

Sulfuric acid (conc)
Nitric acid (conc)
Phosphoric acid
Ammonium hydroxide (conc)
Caustic soda (saturated)
Hydrogen peroxide (3%)
Sodium chloride (saturated)
Xylene
Ethylene glycol
Methanol
Water

Silicon Carbide Foam Withstands 4000 F

It also has good resistance to most chemicals

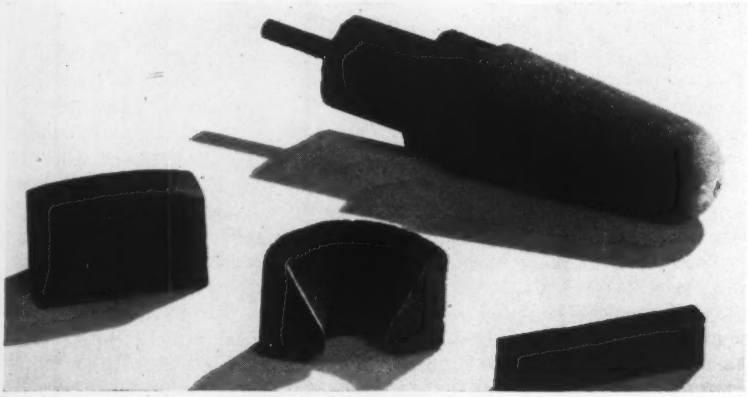
■ Silicon carbide foam has been developed as an insulating material for use at temperatures up to 4000 F. It can be machined with standard steel cutting tools, and can be fabricated into close tolerance, complex shapes. The material, produced in sizes up to 13 x 20 in., is now in pilot plant production at Carborundum Co.'s Research and Development Div., Niagara Falls, N. Y.

PROPERTIES OF SILICON CARBIDE FOAM

PHYSICAL PROPERTIES	
Density, lb/cu ft	
Low Density	17
High Density	33
Max Operating Temp, F	
Oxidizing Atmosphere	3000
Inert Atmosphere	4000
Porosity, %	
Low Density	90
High Density	80
Ther Cond (800-1900 F), Btu/hr/sq ft/°F/ft	
Low Density	7
High Density	12
Coef of Ther Exp, per °F	
800 F	1.99×10^{-6}
1470 F	2.43×10^{-6}
2200 F	2.80×10^{-6}
2450 F	2.91×10^{-6}
MECHANICAL PROPERTIES	
Tensile Strength, psi	
Low Density	30
High Density	70
Compressive Strength, psi	
Low Density	85
High Density	750

Properties and uses

The lightweight, corrosion resistant foam is expected to be used as an insulating material in nuclear reactors, furnaces, missiles and rockets. It is also expected to be used in the chemical



Typical shapes *that can be fabricated from Carborundum's self-bonded silicon carbide foam.*

industry for hot gas and corrosive wet filtration, and catalyst supports.

Corrosion resistance — Because it is self-bonded, silicon carbide foam is highly resistant to most corrosive chemicals and some molten metals. Carborundum engineers have developed dense, self-bonded silicon carbide coatings which impart good abrasion and erosion resistance to the foam.

Mechanical shock resistance— Preliminary studies indicate the foam overcomes some of the mechanical shock problems associated with most hard refractory materials. Impact loading appears to produce localized crushing or permanent deformation without mechanical stress propagation.

Garbage can *showed no damage after . . .*

. . . **Crushing** *by 16-ton trailer.*

Polyethylene Copolymer Is Tough at Low Temperatures

■ A newly developed general purpose, injection molding grade of polyethylene copolymer is said to have outstanding low temperature toughness and a flex life five times longer than polyethylene injection molding materials of similar plastic flow.

A garbage can molded of the new material and tested at 10 F showed no damage after crushing by a 16-ton trailer truck (see photos). The polyethylene cans also withstood 6-ft drop tests at —10 F, whereas cans made of other polyethylene resins were shattered.

The polyethylene copolymer, called DPD-7365, is now available in commercial quantities from Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17. The material, composition of which has not been revealed, is said to be radically different from previously announced ethylene copolymers.

Properties and uses

The resin, developed especially for the housewares market, is expected to find extensive use in a variety of injection molding applications such as outdoor garbage

PROPERTIES OF DPD-7365

PHYSICAL PROPERTIES	
Density, gm/cc	0.935
Melt Index, gm/10 min	8
Brittle Temperature, F	
50% OK	−90
80% OK	−80
MECHANICAL PROPERTIES	
Tensile Strength, psi	1600
Elongation, %	210
Yield Strength, psi	1500
Secant Modulus, psi	40,000
Mechanical Flex Life, no. of flexes[a]	200,000

[a]Tested by flexing compression molded specimens (0.055 in. thick) in a Ross Flex Rubber tester at room temperature. (Conventional 8 melt index resins of equivalent rigidity failed this test in 30,000-40,000 flexes.)

cans, dishpans, baby baths, laundry baskets, wastebaskets, buckets, toys, tool boxes, flashlight cases, tote boxes, vaporizer parts and impeller parts.

Empirical tests indicated that stress cracking resistance of the polyethylene copolymer was about 12 times greater than that of comparable polyethylene resins after exposure to detergents. The tests were conducted as follows:

A ½-in. steel ball was placed under the center of dishpans injection molded from DPD-7365 and 8 melt index polyethylene resins. The dishpans were filled with 1 gal of detergent solution (35 cc detergent per gallon of water) and tested at room temperature.

The dishpans molded from DPD-7365 resin failed in 3 hr at 50% failure level and in 4 hr at 100% failure level. All of the dishpans molded from 8 melt index resins failed in 15 min.

Close Tolerance, Complex Parts Made by Electrolytic Process

by **C. L. Duncan,** *Consultant**

■ Close tolerance, smooth-finished parts in practically any shape or size can be made by a new process called "electrolytic casting." Parts with overall dimensional tolerances of ±0.0005 in. have been made by the process. Dimensions of internal shapes produced by electrolytic casting are as accurate as dimensions of external shapes produced by other techniques.

Complete details as to how the method works are not available at present. However, the method closely resembles electroforming (see box on page 140).

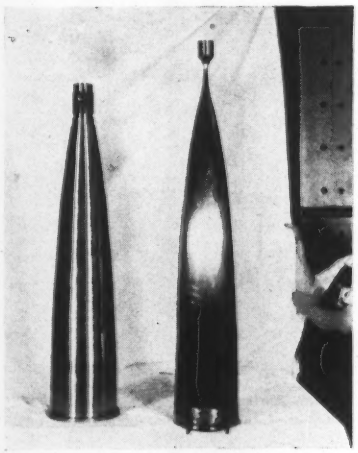
Electrolytic casting extends the scope of electroforming in that it is used to produce thick-walled, heavy products in any size. Parts up to 2 tons in weight and 3 in. in wall thickness have been made by the process. Electroforming is used, for the most part, to make lightweight, thin-walled products such as waveguides, fountain pen bodies and light reflectors.

Metals which lend themselves to electrolytic casting are nickel, copper, iron and silver. Nickel has been used in the process because of its good physical and mechanical properties and good corrosion resistance; also, because it retains its strength at low temperatures, and is a good conductor of heat and electricity. Properties of electrolytic nickel are given in an accompanying table.

(continued on p 140)

PROPERTIES OF ELECTROLYTIC NICKEL

PHYSICAL PROPERTIES	
Density, lb/cu in.	0.322
Specific Gravity	8.9
Melting Point, F	2640
Specific Heat (32-212 F), Btu/lb/°F	0.11
Coef of Ther Exp (32-212 F), per °F	7.5 x 10^{-6}
Ther Cond (32-212 F), Btu/sq ft/hr/°F/in.	470
Elec Res (68 F), microhm-cm	7.0
MECHANICAL PROPERTIES	
Tensile Strength, psi	
Soft Gray Deposits	51,000
Hard Bright Deposits	140-160,000
Elongation (in 2 in.), %	
Soft Deposits	30
Bright Deposits	10
Mod of Elast in Tension, psi	30 x 10^6
Vickers Hardness	
Soft Deposits	150
Bright Deposits	475-525



Electrolytic casting *produces nozzle (left) by electrodepositing nickel on mandrel (right). Rings and slots at the throat end of the nozzle are "cast-in" by special techniques.*

* 2675 Candler Rd., Chamblee, Ga.

MORE WHAT'S NEW IN MATERIALS

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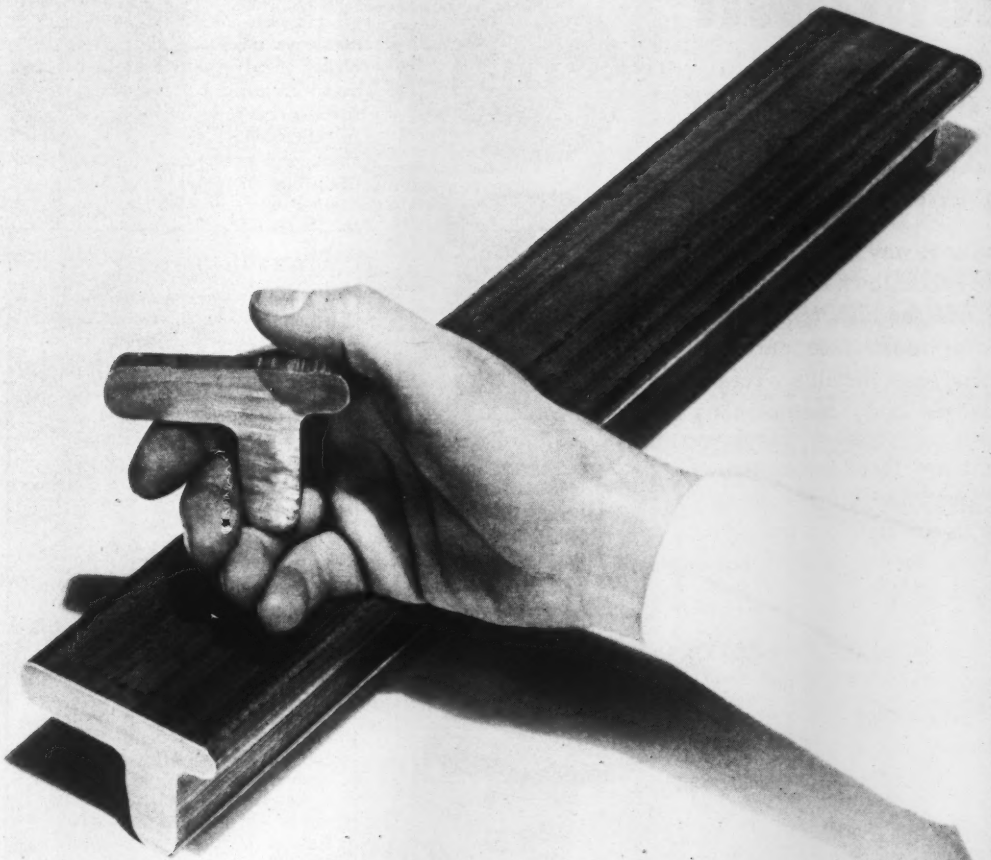

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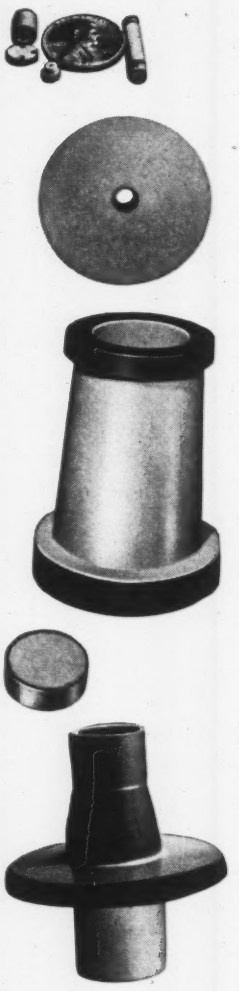

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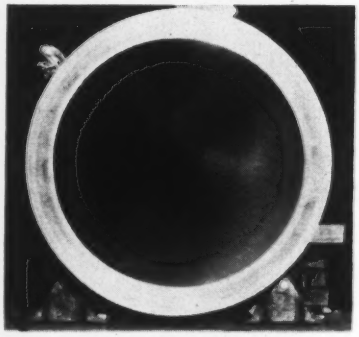

***Front view** of electrolytically cast nozzle.*

Typical application

A typical application for electrolytic casting is the manufacture of a nozzle for wind tunnels. The nozzle is made by electrodepositing nickel on a Type 303 stainless steel mandrel until a structural shell is formed, reproducing internally and in microscopic detail the external shape and surface finish of the mandrel. The completed nozzle weighs 2

Electroforming Process

Electroformed parts are produced by electrolytic deposition of metal on a conductive pattern. Resultant parts conform atomically to the shape and surface of the pattern. Metal is supplied by compounds in the electrolyte and a bar of purified metal suspended in the bath to act as the anode for the plating current.

Electroforming differs from plating in that solid parts are produced with thicker deposits which are later separated from the pattern. Deposited metal exhibits high purity and density with a long, needle-like crystal structure typically aligned at 90 deg to the pattern surface.

A wide range of hardness, ductility and tensile strength can be produced by controlling bath content, rate of deposition, agitation and other bath variables. Though heat treatment of formed parts is possible, it is usually unnecessary. (For more information on electroformed parts, see MATERIALS & METHODS, Sept '55, p 99.)

25
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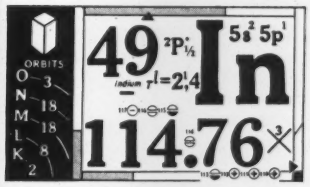

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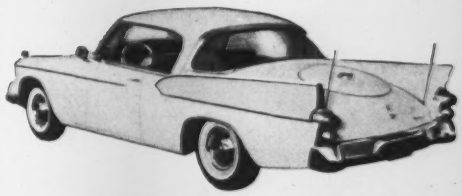

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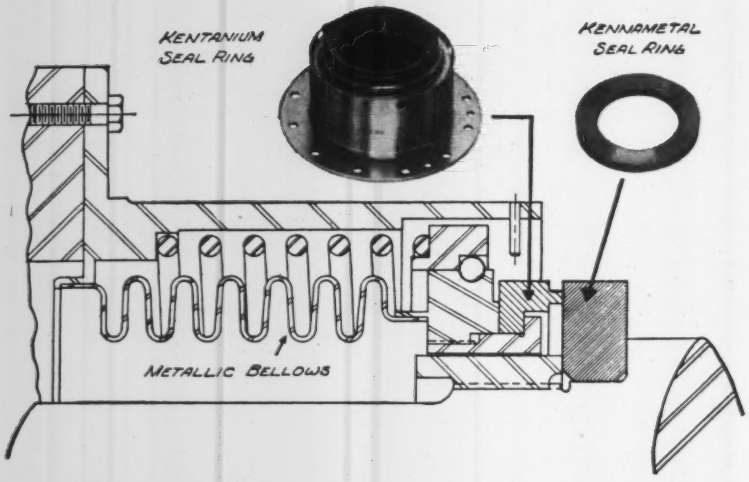

KENNAMETAL* Rotary Seal Rings provide substantially zero leakage at mile-a-minute rubbing speeds

At rubbing speeds of 4200 to 5400 ft./min., the hydraulically balanced seal shown above achieves substantially zero gas leakage. Excellent wear characteristics of the Kennametal and Kentanium* Seal Rings featured in this design make possible unlubricated dry rubbing at peak speeds.

Stein Seal Company, Philadelphia, Pa., solved major sealing problems on many applications by using Kennametal and Kentanium parts in their hydraulic balanced seal design such as illustrated above. By using rings made of these hard carbide, wear-resistant compositions, it is possible to operate with higher spring forces and in much higher temperatures than when rings of conventional sealing materials are used.

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Various grades of Kennametal compositions hold economical answers to *your* need for high YME, low thermal expansion, high resistance to abrasion, erosion, corrosion, impact and pressures. For positive sealing, with little or no maintenance, mating surfaces of Kennametal Seal Rings can be lapped to a flatness less than two light bands, with a surface finish better than two microinch.

For more information, just outline your problem and send it to KENNAMETAL INC., Latrobe, Pa.

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What's new IN MATERIALS

tons, is 12 ft long, and has a wall thickness of 3 in. in certain areas. It has an internal surface finish no greater than 5 μin.

Other techniques used to fabricate the nozzle were not successful. Direct machining was uneconomical because it involved difficult and laborious boring and polishing operations. Nozzles made by pattern casting had to be machined to size and polished internally. Investment casting did not lend itself to the size or tolerances required by the application.

Six Plastics Coatings for Metals, Ceramics

Six new or improved plastics coatings have been introduced during the past few months for use as protective coatings on metallic and nonmetallic products.

1. Vinyl coating

Metal & Thermit Corp., Rahway, N. J., has introduced an abrasion and corrosion resistant vinyl coating called Unichrome B-64. The coating is recommended for use on glass-reinforced polyester and phenolic parts, metal furniture and electronic equipment. The coating is hard and flexible, and withstands perspiration, ink, beverages and commercial cleaning preparations.

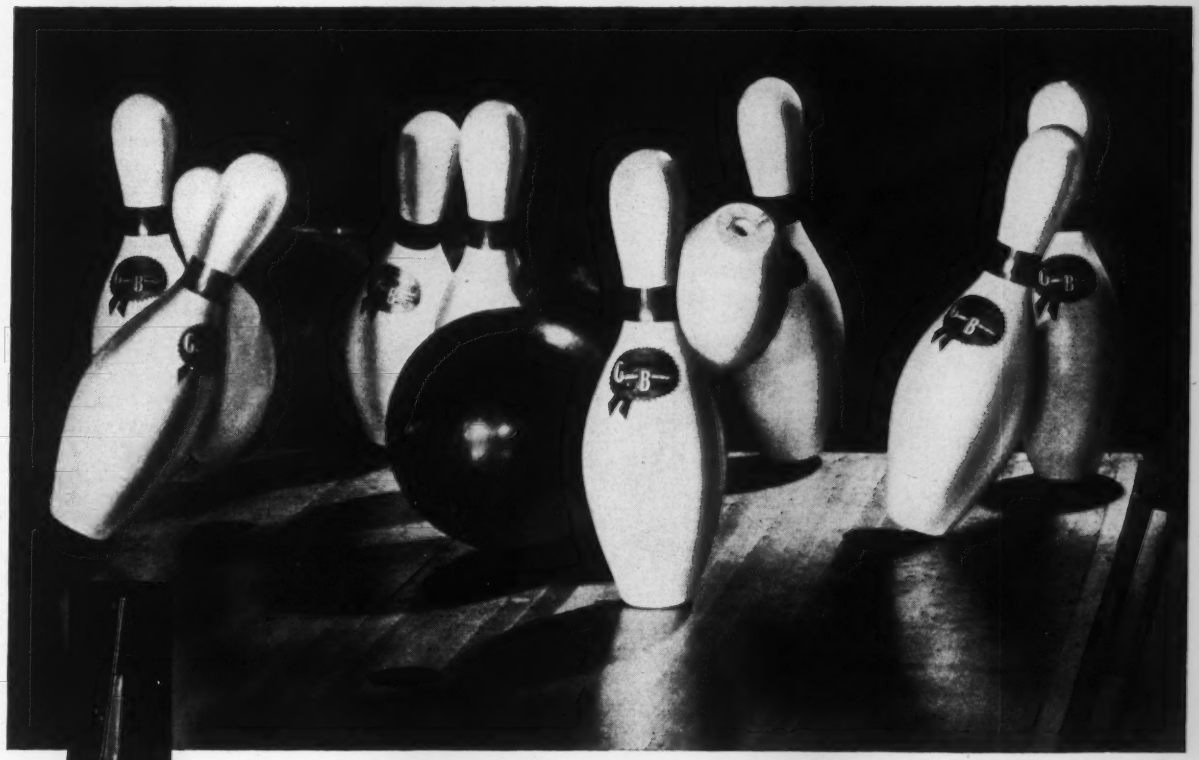
2. Two epoxy coatings

Two epoxy coatings have been developed for use as protective coatings on printed circuit boards and other electronic parts.

PRH 400 is a solvent-based epoxy system developed by Permacel-Le-Page's Inc., U. S. Hwy. No. 1, New

Emerson & Cuming, Inc.

Spraying *clear epoxy coating on printed circuit board.*



from rifle stocks...to bowling alleys...

GAMBLE solves problems with WOOD!

Marksmen found that the slightest swelling or shrinking of their rifle stocks reduced firing accuracy. To solve the problem, a custom gunstock manufacturer turned to Gamble Brothers. Result: a laminated gunstock blank with greater dimensional stability, less tendency to warp, greater strength, and freedom from internal stresses.

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Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers — a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

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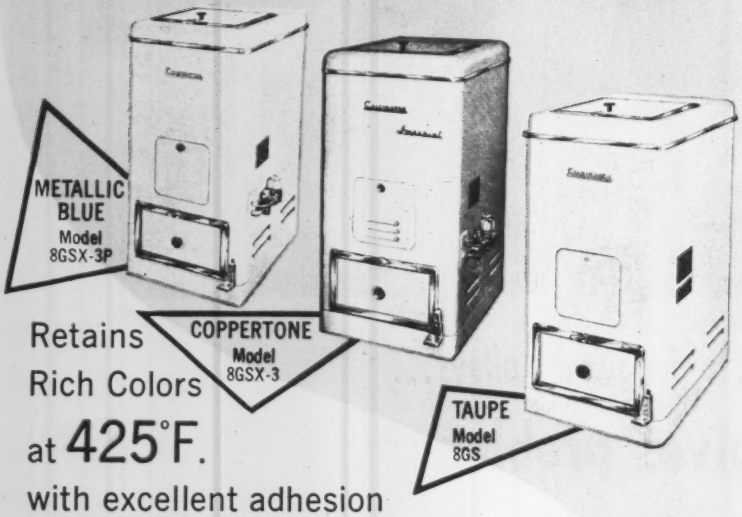

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What's new IN MATERIALS

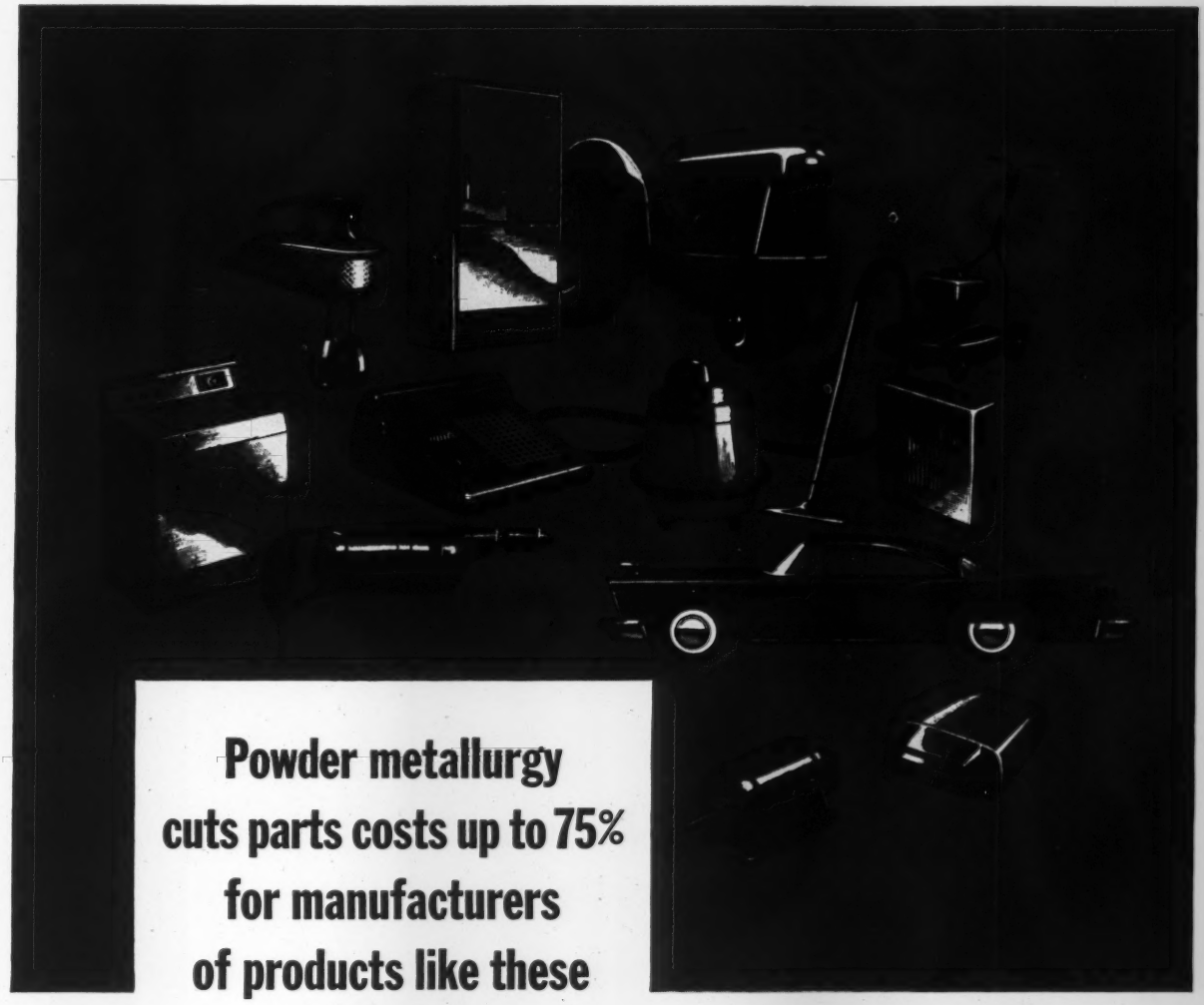
Brunswick, N. J. According to the developer, thin coatings of the product will not crack or craze under severe stresses or prolonged subjection to abrasion, chemicals or moisture. The coating can also be used on plastics, ceramics, metals and concrete.

Eccocoat C 26 is a clear epoxy coating that can be used continuously at temperatures up to 500 F, and intermittently at 600 F. It was developed by Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. The epoxy coating has good electrical properties and good resistance to chemicals and moisture. Eccocoat C 26 is used for coating printed circuit boards, electronic parts, metals and ceramics.

3. Polyethylene coating

A polyethylene resin has been introduced by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. for use as a coating on paper, metal foil and fabric packaging materials. The new material, called Alathon 15, offers improved "neck-down" characteristics without loss of adhesion to the material being coated. (Neckdown, or a tendency to shrink in width prior to coating, affects the caliper of the polyethyl-

Large cold-rolled sheets — Haynes Stellite Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17 has announced the availability of several high temperature alloys in wider cold rolled sheets than were previously available. The thin-gage sheets measure 0.010 in. thick x 36 in. wide x 96 in. long. Alloys currently available as wide sheets include Haynes Alloy No. 25, Multimet, Hastelloy R-235, Hastelloy X and General Electric's René 41 alloy.



Powder metallurgy cuts parts costs up to 75% for manufacturers of products like these

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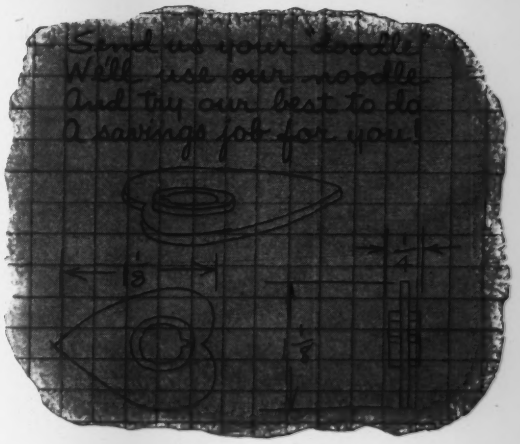

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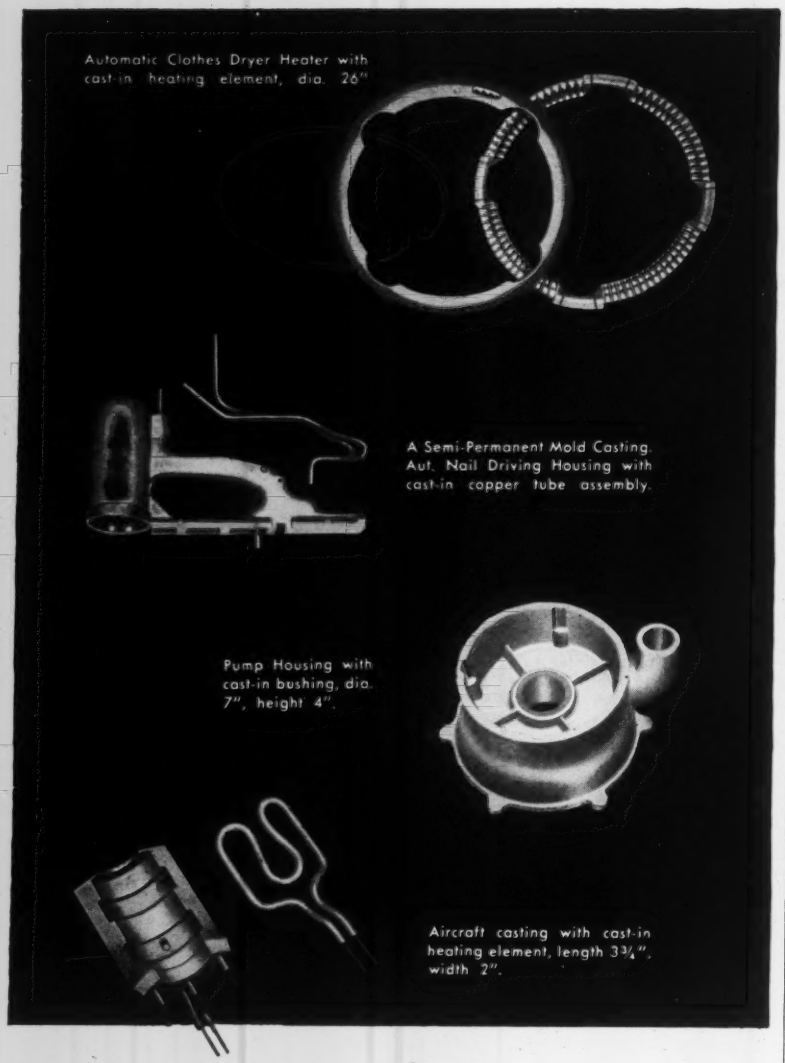
Automatic Clothes Dryer Heater with cast-in heating element, dia. 26"
A Semi-Permanent Mold Casting. Aut. Nail Driving Housing with cast-in copper tube assembly.
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What's new IN MATERIALS

ene layer at its outer edges.) The resin also permits lower heat sealing temperatures.

4. Epoxy-phenolic coating

Union Carbide Plastics Co., Div. of Union Carbide Corp., 30 E. 42nd St., New York 17 has developed a new primer for metal surfaces which combines the advantages of epoxy ester primers with the economic benefits of low cost phenolics. Designated UF-2322, and designed primarily for automotive body work, the material is based on a varnish of 25% epoxy resin and 75% phenolic resin.

5. Isocyanate coating

A new protective coating, based on the reaction of a specially blocked isocyanate and an amine-bearing resin in a water solution, has been developed by Mobay Chemical Co., 1815 Washington Rd., Pittsburgh 34. In formulation, the blocked isocyanate is used in a concentrate of polyamide resin and an emulsifier. The reaction of the blocked isocyanate with the polyamide resin at elevated temperatures results in a polyurea linkage, rather than in the more familiar polyurethane linkage which occurs when isocyanate is reacted with hydroxyl-bearing resins. Advantages claimed for the new one-component system are: 1) good chemical resistance; 2) good adhesion to metals; 3) excellent flexibility; 4) ease of formulation and application; 5) nontoxic properties; 6) noninflammability; and 7) low cost.

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Nickel	8.5-9.5	8.5-9.5	8.5-9.5
Silicon	3.0-3.75	1.25-1.75	3.25-3.75
Manganese	1.0 max	1.0 max	1.0 max
Copper	—	3.25-3.75	2.75-3.25
Molybdenum	3.75-4.25	4.75-5.25	3.75-4.25

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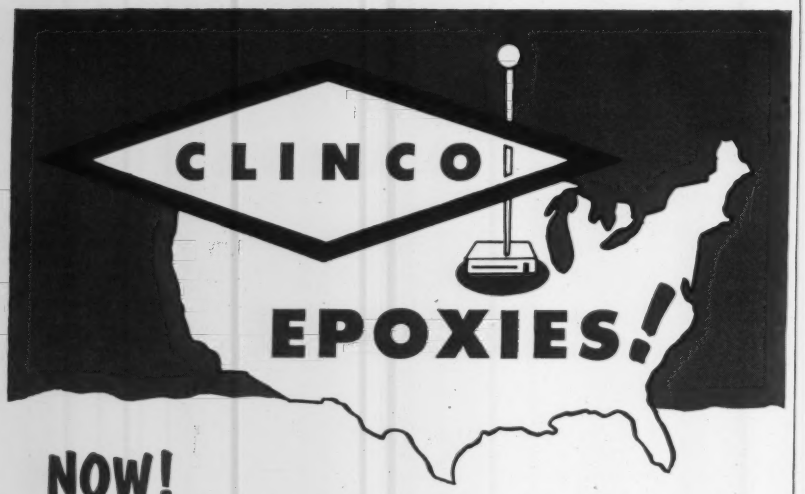

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2-M-310	Mercadium Red

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What's new IN MATERIALS

MECHANICAL PROPERTIES OF PH-55 CASTINGS[a]

Type →	A	B	C
Ten Str, 1000 psi			
Rm Temp	139	138	185
900 F	102	83	108
1300 F	75	63	50
Yld Str, 1000 psi			
Rm Temp	106	105	150
900 F	58	57	57
1300 F	36	32	33
Elongation, %			
Rm Temp	8	21	2
900 F	9	11	6
1300 F	29	22	20
Red. of Area, %			
Rm Temp	6	18	2
900 F	13	9	9
1300 F	42	24	38

[a]Heat treatment: 1 hr at 2050 F, water quench, 8 hr at 900 F, air cool.

has been developed by Cooper Alloy Corp., Hillside, N. J.

The new precipitation hardening alloys are said to have higher strength and hardness, and greater resistance to corrosion (epecially pitting corrosion) and the erosive effects of velocity and suspended abrasives, than precipitation hardening alloys of the corrosion resisting type. According to the producer, the alloys have good strength and corrosive resistance properties at temperatures up to 1400 F.

Three alloys available

PH-55A has high strength, high hardness and excellent corrosion-erosion and corrosion-abrasion resistance. Its resistance to pitting makes it an ideal material for applications where type 316 stainless steel will not stand up.

PH-55B is also a high strength alloy, but has greater ductility and lower hardness than alloy A. Alloy B is particularly suited for applica-

CORROSION RESISTANCE OF PH-55 ALLOYS (ipm)

Type →	A	B
Sulfuric Acid (50%)	0.00156	0.00003
Hydrochloric Acid (5%)	0.04324	0.01260
Nitric Acid (50%)	0.00026	0.00028
Acetic Acid (100%)[a]	0.00003	0.00004
Calcium Hypochlorite (saturated)	0.00002	0.00003
Ferric Chloride (10%)	0.00004	0.01800
Phosphoric Acid (85%)[a]	0.24500	0.08550

[a]Tested at boiling point.

Aircraft Components Manufacturer Specifies

OSTUCO *Forged Tubing*

FOR LOWER MACHINING COSTS

Forging tube end in Shelby mill. In addition, Ohio Seamless can supply tubing flared, swaged, expanded, upset, flanged, shaped, etc.

"Our machining time on this landing gear part in SAE 4140 plummeted from *400 to 180 minutes* when we changed from forgings to Ostuco Forged Tubing.

"In addition to getting *over 80% more parts per workshift*, we like the free-machining qualities of Ostuco tubing that give us extra savings in set-up time and tool grinding costs . . . "

These actual figures, from an eastern manufacturer, indicate the machining economies Ostuco Forged Tubing can effect in your product. The starting point is to call your nearest Ohio Seamless office, listed in the Yellow Pages, or the plant at *Shelby, Ohio — Birthplace of the Seamless Steel Tube Industry in America.*

AA-3850

OSTUCO SHELBY OHIO — OSTUCO TUBING

OHIO SEAMLESS TUBE DIVISION

of Copperweld Steel Company · SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, St. Petersburgh, Salt Lake City, Seattle, Tulsa, Wichita · CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

For more information, turn to Reader Service card, circle No. 409

DESIGN ENGINEERS ASK US ABOUT

4-D WROUGHT IRON FOR:

Condenser and Heat Exchanger Tubing

Comparative cost-per-foot-per-year figures reveal 4-D Wrought Iron's wide margin of economy over steel. Scores of service records substantiate 4-D's longer tubing service life at lower cost-per-foot-per-year in a wide variety of heat exchanger and condenser tubing applications.

Chimney Corsets

Cost-conscious engineers are making 4-D Wrought Iron a standard spec for corrosive chimney corset service. The corsets are fabricated from 3″ x ⅝″ 4-D Wrought Iron bars. They're installed between the fire brick lining and the outside wall of the chimney for support.

Slop Run-Off Lines

Oil companies use 4″ galvanized 4-D Wrought Iron Pipe to carry off corrosive slop in cleaning tank barges. Hot salt water and residue oil discharged through the lines are dangerously corrosive. 4-D Wrought Iron assures continuous service.

Piping in Asphalt Softeners

Tank heater shells, 20′ in length, fabricated from 23″ O.D. Wrought Iron Pipe, are more than a match for corrosion in asphalt softening chores. Three-inch fins spaced every 8″ on the outside of the shell minimize buckling and increase heat transfer. Temperatures within the heater reach a maximum of 800°F. Service records show steel doesn't hold up.

1000°-1500°F Boiler Tubes

Calorizing of 4-D Wrought Iron for high-temperature service adds even greater staying power to this rugged material. Calorizing couples high heat resistance with 4-D's excellent resistance to oxidation and sulphur corrosion. Gives boiler tubes, thermocouples, and other high-heat units a new lease on life.

If you're inquiring, write:

Product Development Department

A. M. BYERS COMPANY

Clark Building, Pittsburgh 22, Pa.

For more information, circle No. 496

What's new IN MATERIALS

tions where parts are subjected to stress and shock.

PH-55C has better corrosion resistance, higher hardness and strength, and slightly less ductility and shock resistance than alloy A.

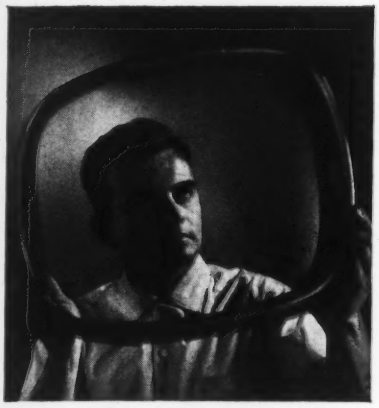
Potential uses

The three precipitation hardening alloys are expected to be used in chemical process equipment handling corrosive media.

Alloys A and C appear to be excellent materials for pump casings and impellers, particularly in applications involving corrosion, velocity, abrasion and wear. Because alloy A has good resistance to pitting-type corrosion, it is suited for use in marine hardware and for handling bleach solutions in the textile industry. The combination of high strength and ductility found in alloy B recommend it for vibratory and highly stressed corrosive applications such as disintegrators and pressure reactors.

The good heat resistance of some

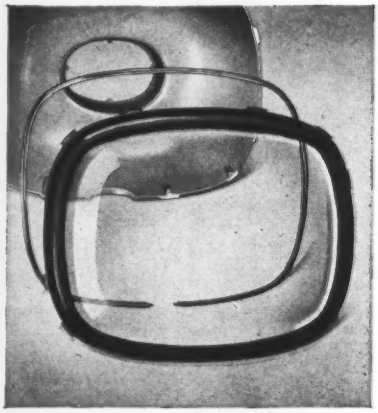
Polystyrene foam insulation — Large pieces of expanded polystyrene foam such as that shown here can be sawed into any length and thickness for use as thermal insulation. The rigid foam plastic is produced under controlled conditions of heat and pressure by Gilman Bros. Co., Gilman, Conn. It is called Cellulite. Potential uses include: thermal insulation, packaging material for delicate instruments and electronic tubes, life saving equipment, nonsinkable boats and floating toys. The new product weighs slightly more than 1 lb per cu ft, and is shock and water resistant.



1 PROTECTIVE FACE for picture tube housing is a one-piece injection molding of Tenite Butyrate plastic. Dark strip around edge is a "frame effect" created by painting the inside border. Molded for Philco by Buffalo Molded Plastics, Inc., Erie, Pa.

Tenite Butyrate has two jobs in new Philco TV sets

2 DECORATIVE TRIM STRIP that conceals the joint between Butyrate face plate and rear shell of tube housing is an extrusion of Tenite Butyrate. Strip is extruded with an aluminum foil insert to simulate a metal molding. Trim strip, post-formed to conform to shape of housing, is supplied by Anchor Plastics Co., Inc., Long Island City, N.Y.



Philco takes the picture tube out of the chassis ...protects it with a face of tough Butyrate plastic

The new line of Philco Predicta TV sets is another example of how Tenite Butyrate plastic can be used to improve the design and sales appeal of products.

Thanks to the toughest "face" on TV—a one-piece molding of clear Tenite Butyrate, tinted to minimize glare—Philco now features a picture tube that is dramatically set apart from the chassis.

Although many factors contributed to the choice of Butyrate here, the basic consideration was its inherent toughness, since a separated picture tube would be exposed to extra hazards.

In Butyrate, Philco engineers found a material with all the toughness and impact resistance they needed. Moreover, this Eastman plastic also satisfied the other requirements involved... light weight... optical clarity... resilience... easy moldability... high dielectric strength.

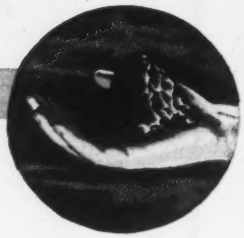
Incidentally, the color that imparts an eye-easing tint to the face is part of the plastic itself. Philco designers were able to specify the color desired, and Tenite molding compound was supplied to the molder in an exact match. Result: the tinting color is an integral part of the face, not merely a coating that might wear, chip or flake off.

If you are designing or redesigning a product, consider Tenite Butyrate whenever you need a truly tough plastic. Easy to mold, extrude or vacuum-form, Tenite Butyrate is available in clear and colored transparents, translucents, opaques, metallics, and variegations to match your specifications. For more information, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE
BUTYRATE
an Eastman plastic

For more information, turn to Reader Service card, circle No. 431

PROGRESS REPORT



Fabricating Columbium Alloys

First, let's settle the question "When is columbium niobium?" It depends on whether you're a chemist or a metallurgist. And since we are interested mostly in metallurgy at the TAPCO Group, we call it *columbium*.

Columbium is growing more and more interesting to the people with product design problems involving high operating temperatures, greater stresses, and severe oxidizing conditions. In fact, it is rapidly overtaking molybdenum as the expert's choice for refractory structural materials.

Because of this increased interest in columbium, now available in sufficient quantities, the TAPCO Group has been conducting an extensive columbium development program during the past eighteen months. This program, a joint venture with E.I. duPont de Nemours & Co., Inc., has contributed much information about the properties of columbium and has produced better methods of working with it.

ABOUT WORKABILITY—At TAPCO, forging methods have been investigated with a variety of columbium extruded bars. Excellent progress is being made on jet engine parts and missile structural components. One method used to produce turbine blades includes heating blanks to forging temperature in an Argon-flooded furnace, then press-forging them in conjunction with a TAPCO-developed die lubricant. Simple surface-polishing is all that is needed to finish these precision-forged parts.

An important phase of the TAPCO program is the development of welding procedures for columbium alloys. TAPCO welding engineers have successfully joined columbium by spot and seam resistance methods, have also fusion-welded columbium sheets successfully.

WHAT DOES COLUMBIUM OFFER? If you design or build aircraft engines, missiles or supersonic airframes, you'll be interested in the research the TAPCO Group and duPont have done to improve columbium properties.

It has excellent strength and shock resistance at greatly elevated temperatures... up to 2600 F, even 3000 F with some alloy compositions.

Now, about columbium *vs.* molybdenum. Columbium is easier to fabricate than moly. And much, much more resistant to elevated-temperature oxidation. For example, a simple columbium alloy is as much as 100 times better than moly on oxidation resistance. And a complex columbium alloy may be as much as 500 times better.

At TAPCO, coating materials for columbium are being developed, including one that reduces the oxidation of columbium at 2200—2300 F to practically zero.

WHERE TO USE COLUMBIUM—Columbium blades for jet engine turbines are an actuality... we'll be glad to show you finished forgings. Columbium also makes sense for such other jet engine "hot zone" parts as vanes, turbine wheels, after-burner liners, nozzles and nozzle flaps, and burner holders.

The use of columbium sheet seems very promising for missile structural components, such as leading edges, hinges, brackets, and the "ribs" and "skin" for airframes.

We would welcome an opportunity to tell you more about TAPCO's columbium research, and to discuss with you the many exciting possibilities of this space-age metal.

TRW

TAPCO GROUP

Thompson Ramo Wooldridge Inc.

Dept. MD-759 • Cleveland 17, Ohio

For more information, turn to Reader Service card, circle No. 384

of the alloys makes them useful in missiles and aircraft.

Heat treating, fabricating

Heat treatment consists of heating to 2050 F for 1 hr plus 1 hr per in. of maximum cross section. The slight discoloration that results from heat treating is said to have no effect on corrosion resistance.

The steels reach maximum softness for cold working or machining after quenching in water. The three alloys are easy to drill, turn or thread in the quenched condition.

The alloys can be welded by the shielded argon technique, using rod of similar composition. After welding, a re-solution anneal is recommended for uniformity of properties and maximum corrosion resistance.

Although the three alloys are produced in the cast form, rolled bar stock has been made from alloys A and C on an experimental basis. Of the three alloys, alloy A is the easiest to forge and roll. The ductility of the wrought material is generally superior to that of cast material; strength is about the same for both materials at equivalent hardness levels.

Rayon Reinforcement for Rubber Goods

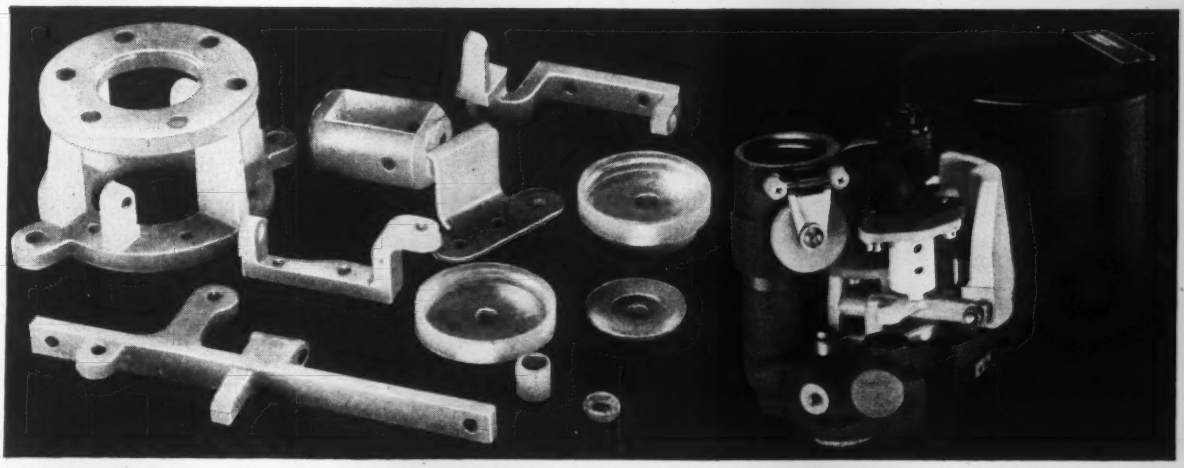
Development of a new adhesive-finished high tenacity rayon yarn for reinforcing such mechanical rubber goods as conveyor belts and braided hose has been announced by E. I. du Pont de Nemours & Co., Inc., Textile Fibers Dept., Wilmington 98, Del. The rayon yarn, called Super Cordura Type 272-F can be processed on conventional industrial weaving equipment.

Advantages

The new product is said to reduce processing costs, decrease inventory requirements, and eliminate the need for adhesive-dipped fabrics with short shelf life. In addition, closer control of fabric construction is possible through elimination of the shrinkage which can occur in conventional fabric dipping.

Tests show that Type 272-F rayon gives adhesion values greater than 20 psi in many types of natural and synthetic rubber stocks. This value compares favorably with values for

New ideas in NYLON



14 parts made of Spencer Nylon, all inter-related and inter-working, go into this new valve developed by Aero Supply Mfg. Co. The parts are molded to exact tolerance by Plastic Molded Parts, Inc.

Spencer Nylon Chosen For Exact-Tolerance Valve Assembly

How Spencer Nylon 600 met the rigid requirements of Plastic Molded Parts, Inc., in molding a new aircraft valve assembly for Aero Supply Manufacturing Co.:

A new aircraft fuel system valve assembly, created by Aero Supply Manufacturing Company of Corry, Pa., has 14 nylon parts, plus a few metal parts. Tolerances on all 14 of the inter-related and inter-working nylon parts must be maintained to the degree that they make up a functioning unit!

The job of molding the nylon elements was assigned to Plastic Molded Parts, Inc., of East McKeesport, Pa.

Spencer Nylon The Answer

To mold parts with the exact tolerances needed in this application required a material with low shrink value. Plastic Molded Parts tested two different brands of nylon and chose Spencer Nylon for the job.

Because component parts made of Spencer Nylon are metal-strong and plastic light, more and more designers and manufacturers are looking to this wonder-material to solve problems of weight—without sacrificing strength or durability.

Special Properties Solve Problems

Besides strength and lightness, Spencer Nylon offers the advantages of extreme abrasion resistance and low friction properties, plus an additional, unique feature: Spencer Nylon is self-lubricating!

If you are faced with a product problem, why not investigate the special properties of Spencer Nylon. You, too, may discover that Spencer Nylon can supply the answer you have been seeking.

For more information on Spencer Nylon, write direct to Spencer Chemical Company, Dwight Bldg., Kansas City 5, Mo.

SPENCER®

SPENCER CHEMICAL COMPANY

SPENCER NYLON

General Offices. DWIGHT BUILDING, KANSAS CITY 5, MISSOURI

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PUREBON

SELF-LUBRICATING

DIMENSIONALLY STABLE

OXIDATION RESISTANT

CHEMICALLY INERT

CONSTANT FRICTION

*carbon-graphite especially designed for mechanical applications

PUREBON is ideal for bearings, seals, blades and similar sliding or rotating parts which must be self-lubricating . . . dimensionally stable at high temperatures . . . oxidation resistant . . . chemically inert . . . and provide constant friction. Purebon is light in weight . . . readily machinable . . . and low cost when molded to size. Why not send your prints to us . . . Purebon is solving similar problems daily for design engineers everywhere.

Request Bulletin No. 59 or see Sweet's Product Design File

PURE CARBON CO., INC.
448 HALL AVE., ST. MARYS, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 379

cotton and resorcinol-formaldehyde-treated rayons.

The adhesive-finished rayon yarn has 40% greater retention of adhesion when wet as compared with conventional resorcinol-formaldehyde-treated rayon. It also has higher yarn friction and better shelf life.

Coated Molybdenum Withstands 1800 F

Two significant developments toward improving the performance of gas turbine engines have come out of research at General Electric Co.'s Flight Propulsion Laboratory, Cincinnati, Ohio. One development is a four-layer oxidation resistant coating for molybdenum turbine buckets. The other is a process for drawing molybdenum tubing and subsequently forming the tubing into seamless turbine nozzle partitions.

1. Oxidation resistant coatings

Of approximately 50 coating systems evaluated, the four layer coating seems to be the best one to date, according to M. A. Levinstein who described GE's research work at a recent meeting of the American Society of Metals. The four layer coating consists of: 1) a chromium electroplate to give a diffusion-type bond; 2) a nickel electroplate to improve ductility; 3) a fused nickel-silicon-boron coating as a bonding layer for Nichrome cladding; and 4) a 0.006-in. brazed layer of Nichrome hard surfaced with a chromium-tungsten-cobalt-boron alloy as a final cladding (see Fig 1).

In the coating process, the bucket

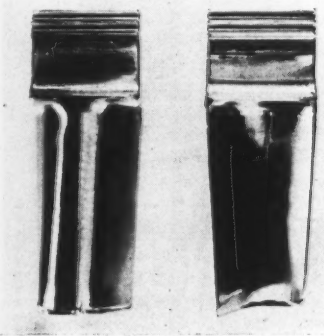


Fig 1—Fully clad turbine buckets.

IMPACT VS. PLASTIC LAMINATES

It's more than "How Much" and "How Often"

It is easier to picture impact than to describe the effects of it upon plastic laminates such as Synthane. For one thing, impact is measured in several ways. In the standard A.S.T.M. (Izod) test notched samples ½" x ½" x 2½" are struck by a pendulum. This test is an accepted standard yet it seldom measures the impact behavior upon plastic laminates. Reason: certain grades of laminates are "notch sensitive", a condition which they may never meet in a practical application.

Nor does the Izod test indicate the ability of Synthane to resist repeated blows. Figure 1 shows how many times blows of a pre-determined intensity can be absorbed before the material breaks down.

Temperature Affects Impact Strength

Even repetitive impact is not the whole of the story. Temperature has an interesting effect upon impact strength (Izod). The curves in Figure 2 show that at extremely low temperatures glass-base grades of Synthane actually improve in impact strength, while other grades improve as they are warmed. The impact strength of Glass Epoxy Grade G-10 improves sharply at temperatures above 75° F.

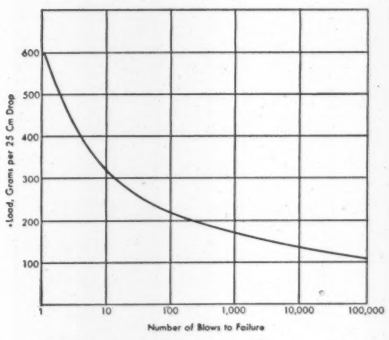


FIG. 1 Intensity of impact vs. cycles

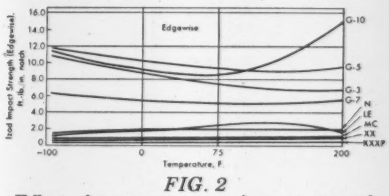


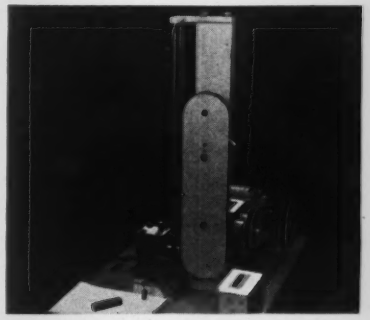
FIG. 2
Effect of temperature on impact strength

Impact Rarely Travels Alone

Like so many other properties of laminates, impact strength can rarely be regarded alone; it must be related to other properties required for the application. A sheet of Synthane has less impact strength than an equal thickness of steel. But steel is over seven times heavier and is a conductor, not an insulator. It is the combination of other properties desired, including impact strength, that is decisive.

Typical applications for Synthane's combined properties under impact conditions are (a) Grade LE Synthane in the shock struts of Airplane Landing Gear (light weight, low coefficient of friction, compressive strength, wear and shock resistance); (b) Welding Tong Insulation, made from G-5 Synthane (high resistance to impact, excellent resistance to heat, and good dielectric strength); (c) Ignition Breaker Arms of Grade C molded-laminated Synthane (impact resistant, wear resistant, dielectrically strong).

If you have any question about the selection of the proper grade of Synthane for your impact application refer it to us directly or to a Synthane representative. Make sure you obtain the most of what you want for the money. For information write Synthane Corp., 3 River Road, Oaks, Pa.



Synthane laboratory machine for measuring impact fatigue.

SYNTHANE

CORPORATION, OAKS, PENNA.

Laminated Plastics for Industry

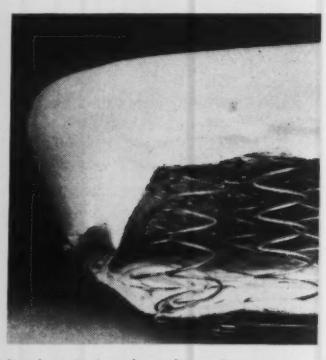
Sheets, Rods, Tubes, Fabricated Parts
Molded-laminated, Molded-macerated

For more information, turn to Reader Service card, circle No. 383

REYNOCOIL

COMBINES SPRING AND FOAM TO CREATE A TOTALLY NEW DIMENSION IN SEATING

America's pioneering urethane foam specialists, Reynolds Chemical Products Company, in conjunction with the automotive industry and the spring division of Stubnitz Greene Corporation, has once again brought a new concept of seating to the nation.



Steel spring and urethane foam merge to combine the structural and comfort advantages of both seating techniques. Cut-away shows interior of automotive seat.

Now a new ultimate in seating comfort — and for manufacturers remarkable cost reductions — are possible through the marriage of spring and foam into a single seating unit.

In pilot production today, this new seating development promises untold new horizons in design, in manufacture and in consumer comfort.

For complete details on this totally new development, write or wire Reynolds Chemical Products Company today.

REYNOLDS CHEMICAL PRODUCTS COMPANY

Whitmore Lake, Michigan • Phone HIckory 9-9361
DIVISION OF STUBNITZ GREENE CORP.

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***Fig 2**—Seamless partition.*

is first electropolished in sulfuric acid, then chromium plated. The chromium electroplate is vapor blasted to remove surface oxides, then nickel plated. After plating the bucket is heat treated in dry hydrogen at 2100 F to diffuse the chromium to the molybdenum and the nickel to the chromium. The nickel electroplate is grit blasted, then flame sprayed with a nickel-silicon-boron alloy. The flame sprayed coating is fused to the nickel electroplate in a special retort. Finally, the Nichrome plate is brazed to the fused nickel-silicon-boron coating.

Coated buckets have been subjected to both steady state and cyclic engine tests. In an 1800 F steady state test, a wheel of 96 buckets ended 50 hr with only two bucket failures—one after 34 hr, the other after 44 hr. The failures were caused by coarse particles in the turbine gas stream penetrating the coating. The bucket that failed after 34 hr sustained initial impact damage between 25 and 30 hr at which time the coating had been penetrated down to the base molybdenum. However, it was

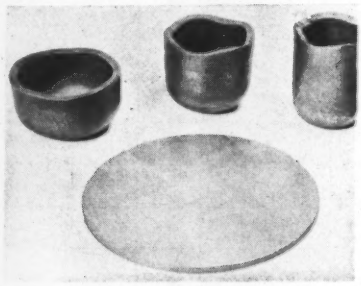


***Fig 3**—Fully annealed molybdenum alloy disk is drawn into a cup in three successive operations.*

HOW TACO USES WOLVERINE TRUFIN® TYPE W/H

For a Smaller Water Heater To Provide More Hot Water!

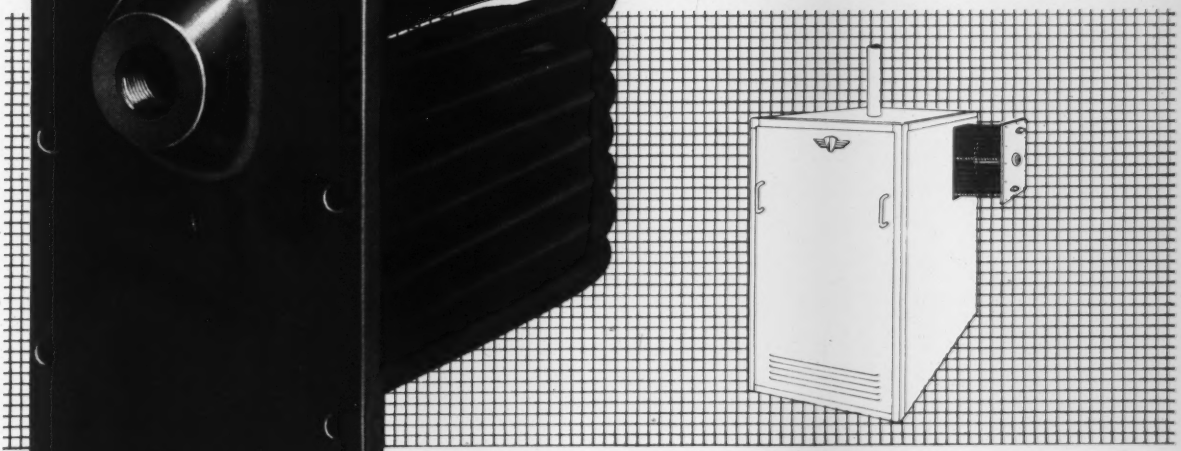
At Taco Heaters Incorporated, Cranston, R. I., design engineers have solved the modern trend to smaller, more efficient products.

As one of the leading suppliers of water heaters to America's boiler manufacturing industry, Taco licked this problem by designing its water heaters around Wolverine Trufin Type W/H — the integrally-finned condenser tube made expressly for water heater use.

Here's how a Taco spokesman described his company's success: "In the 'old days', boilers were large in size and there was plenty of room available for water heaters fabricated from prime surface tubing. However, as time went on, new boiler designs became smaller and smaller — and so did the space available for the water heater.

"Since the introduction of Wolverine Trufin we can now pack more heat transfer surface into less space, thus getting the entire water heater into the boiler. This enables the boiler manufacturer to improve unit appearance and efficiency at lower cost."

There's a good chance that Wolverine Trufin's ability to transfer more BTU's per foot of tube can help your company just as it did Taco Heaters Incorporated. Why not talk over your problem with one of Wolverine's highly-trained Sales Representatives? Write, too, for a copy of Wolverine's "The Way To BETTER WATER HEATERS" catalog.



Wolverine Trufin is available in Canada through the Unifin Tube Division, London, Ontario

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION

In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
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WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17258 Southfield Road
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Manufacturers of Quality-Controlled Tubing and Extruded Aluminum Shapes

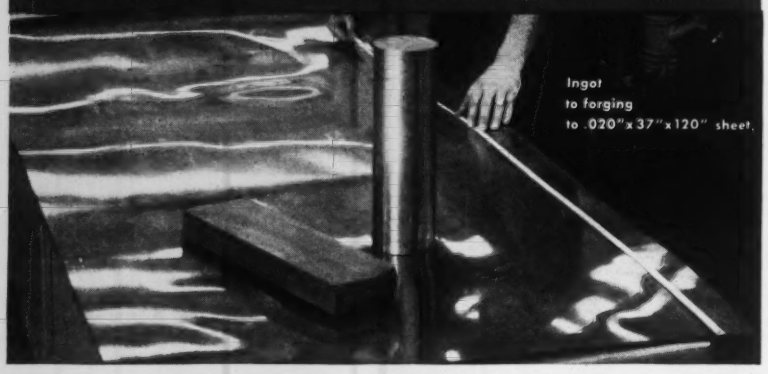
PLANTS IN DETROIT, MICHIGAN, AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES.

For more information, turn to Reader Service card, circle No. 478

2 MORE FANSTEEL SPACE-AGE ALLOYS

with

High Strength-To-Weight at HIGH TEMPERATURES



FANSTEEL 80 METAL

Alloy—Columbium-zirconium

Melting Point—4350°F.

Density—
8.6 grams per cc (0.311 lb. per cu. in.)

Tensile Strength—
Annealed 70°F.; 47,000 psi.

Stress-To-Rupture—
100 hr. 2000°F.
(argon) 18,800 psi.
500 hr. 2000°F.
(argon) 11,000 psi.

Other Properties—Ductile to brittle transition temperatures in annealed state are well below room temperature.

Advantages and Uses—Extremely high strength-to-weight ratio for high temperature applications. Excellent weldability, ductile welds with little or no tendency to fracture in heat affected zones. Easy fabrication at room temperature, as worked or annealed. For missiles, rockets, spacecraft, other high heat applications.

FANSTEEL 82 METAL

Alloy—Columbium-tantalum-zirconium

Melting Point—4550°F.

Density—
10.26 grams per cc (0.371 lb. per cu. in.)

Tensile Strength—
Annealed 70°F.; 55,000 psi.
2000°F. in air; 29,600 psi.
2400°F. in air; 11,700 psi.

Stress-To-Rupture—
100 hr. 2000°F. (argon) 17,500 psi.
500 hr. 2000°F. (argon) 13,500 psi.

Other Properties—High oxidation resistance compared to pure refractory metals. Oxide film is tenacious, non-volatile, tends to form protective coating. 16-hour, 2000°F. tests in flowing air show remarkably low scaling of 0.01 cm.

Advantages and Uses—Exceptionally suitable for air-frames and certain missile applications. Provides desirable strength-to-weight advantages at higher temperatures plus the same workability, weldability and ductility of Fansteel 80 Alloy.

AVAILABLE in ingots, forgings, bar, rod, plate, sheet and fabricated parts. Write for latest technical bulletins.

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What's new IN MATERIALS

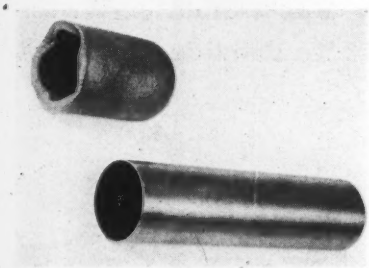

***Fig 4**—Roll forming increases the length of drawn cup from 1.9 in. to over 7 in.*

not until 34 hr that sufficient molybdenum had oxidized to throw the wheel out of balance. This delay indicated that the rate of molybdenum oxidation is governed by the size of the hole in the coating, and the bucket can still perform for a number of hours after the coating has been penetrated.

The cyclic tests were made at 1900 and 2000 F. Life of coated buckets was approximately half that attained under steady state conditions after cycling 24 min at 2000 F and 36 min at 1900 F. Chief cause of failure in cyclic testing was thermal fatigue, not impact damage. Thermal fatigue resulted from the wide difference in coefficient of expansion between the nickel portion of the coating and the base metal. (For more information on oxidation resistant coatings for molybdenum, see MATERIALS & METHODS, Dec '56, p 84.)

2. Seamless turbine partitions

Protectively coated seamless molybdenum alloy partitions in gas turbine nozzle assemblies (Fig 2) show promise of operating at temperatures over 2000 F, according to J. W. Forry and D. G. Freark of GE's Flight Propulsion Laboratory. The seamless partitions are said to greatly improve the effectiveness of the protective coating in comparison with previously used welded or brazed partitions.

The seamless partitions are produced by a new manufacturing method in which molybdenum alloy is drawn and formed into tubing at temperatures from 800 to 1000 F. In addition to tubing, the method shows promise of producing intricate molybdenum shapes, thus greatly increasing the potential uses for

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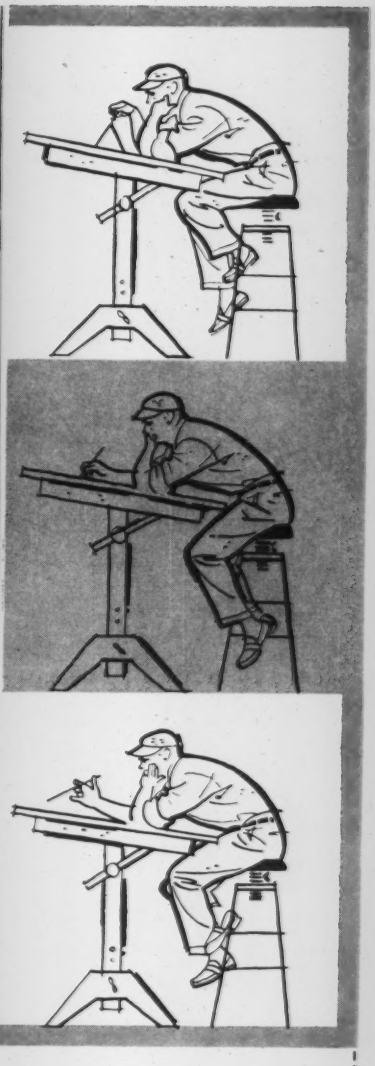

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What's new IN MATERIALS

the metal. Seamless molybdenum alloy tubing is produced in the following sequence:

1. A cup is drawn in three successive operations from a fully annealed molybdenum alloy disk (see Fig 3). Tools are kept hot, and drawing is done at the lowest possible press speed. The drawn cup is trimmed and finish machined prior to roll forming.

2. The drawn cup is roll formed on a standard lathe fitted with a special roller assembly. Roll forming is done at temperatures between 800 and 1000 F. Length of the drawn cup is increased from 1.9 in. to over 7 in. after roll forming (see Fig 4).

3. The closed end and the excess length of the roll formed tubing is trimmed to produce a tube 4.25 in. long x 1.50 in. o.d. x 0.032 in. wall thickness. The trimmed tubing is then stress relieved.

Fluoride Films for Electrical Insulation

Nonporous, flexible fluoride films provide high temperature electrical insulation on copper, aluminum and other metal wires.

Research conducted by S. S. Flaschen and P. D. Garn of Bell Telephone Laboratories, 463 West St., New York 14, shows that the fluoride films have excellent resistance to oxidation when heated over 1100 F and have good resistance to high humidity. The insulation ranging in thickness from 1 to 2 μ, retains its

Researchers *Flaschen and Garn inspect a fluoride-coated aluminum strip after subjecting it to high temperatures in a small furnace.*

II

KNOW YOUR ALLOY STEELS . . .

This is the second of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Effects of Elements Used in Alloy Steels

To simplify a rather complex subject, let's outline some of the individual effects of four leading alloying elements used in alloy steels:

Nickel—One of the fundamental alloying elements, nickel provides such properties as deep hardening, improved toughness at low temperatures, low distortion in quenching certain types of tool steels, good resistance to corrosion when used in conjunction with chromium in stainless grades, and ready response to economical methods of heat-treating.

Chromium—This element is used extensively to increase the corrosion-resistance of steel. It also improves the surface resistance to abrasion and wear. It exerts a toughening effect and increases the hardenability.

Molybdenum—This element exerts a strong effect on the hardenability and toughness of steel. It greatly increases short-time and long-time strength at high temperatures.

Vanadium—An element used to refine the grain and enhance the mechanical properties of steel.

A combination of two or more of the above alloying elements usually imparts some of the characteristic properties of each. For example, chromium-nickel grades of steel develop good hardening properties with excellent ductility. And chromium-molybdenum steels develop excellent hardenability with satisfactory ductility and a certain amount of heat-resistance. In other words, the total effect of a combination of alloying elements is usually greater than the sum of their individual effects. This interrelation must be taken into account whenever a change in a specified analysis is evaluated.

Bethlehem metallurgists can be of considerable help to you in selecting the proper alloy steel for any use. These men will gladly give unbiased advice on alloy steel analysis, heat-treatment, machinability, and expected results. Feel free to call upon them at any time.

And please remember, too, that Bethlehem manufactures all AISI standard alloy steels, as well as special-analysis steels and the full range of carbon grades. You can rely upon their quality, always.

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dielectric strength even at 450 v at 900 F.

The fluoride films are formed directly on freshly cleaned copper or aluminum by exposing the metals to oxidizing carriers of fluorine such as hydrogen fluoride or elemental fluorine at temperatures from 500 to 1100 F. The thickness of the resulting copper fluoride and aluminum fluoride films depends on the temperature at which they are formed, the concentration of fluorine, and the time of exposure. Aluminum forms a fluoride film 1 μ thick in a few minutes at 1000 F. Aluminum fluoride films have an electrical insulation value of 10^{10} ohms at room temperature and 7×10^{8} ohms at temperatures as high as 900 F.

According to Bell Telephone Laboratories, the insulating fluoride films should be satisfactory at temperatures almost up to the melting point of the conductor on which they are coated. The best organic insulating coating cannot be used continuously above 500 F.

Small Tubing Made of A-286 Superalloy

Small tubing of A-286, an austenitic alloy of approximately 55% iron, 25% nickel and 15% chromium, has been successfully cold drawn by Superior Tube Co., 1548 Germantown Ave., Norristown, Pa., and is now being offered commercially for high temperature applications.

Standard size limits are 0.012 to 0.625 in. o.d. for seamless tubing and 0.0625 to 0.625 in. o.d. for welded tubing. Three standard tempers—solution annealed, half hard and full hard—are supplied.

Tubing made from A-286 is expected to be used in gas turbine structures and fuel lines and as aircraft mechanical and hydraulic tubing. The tubing is also promising for

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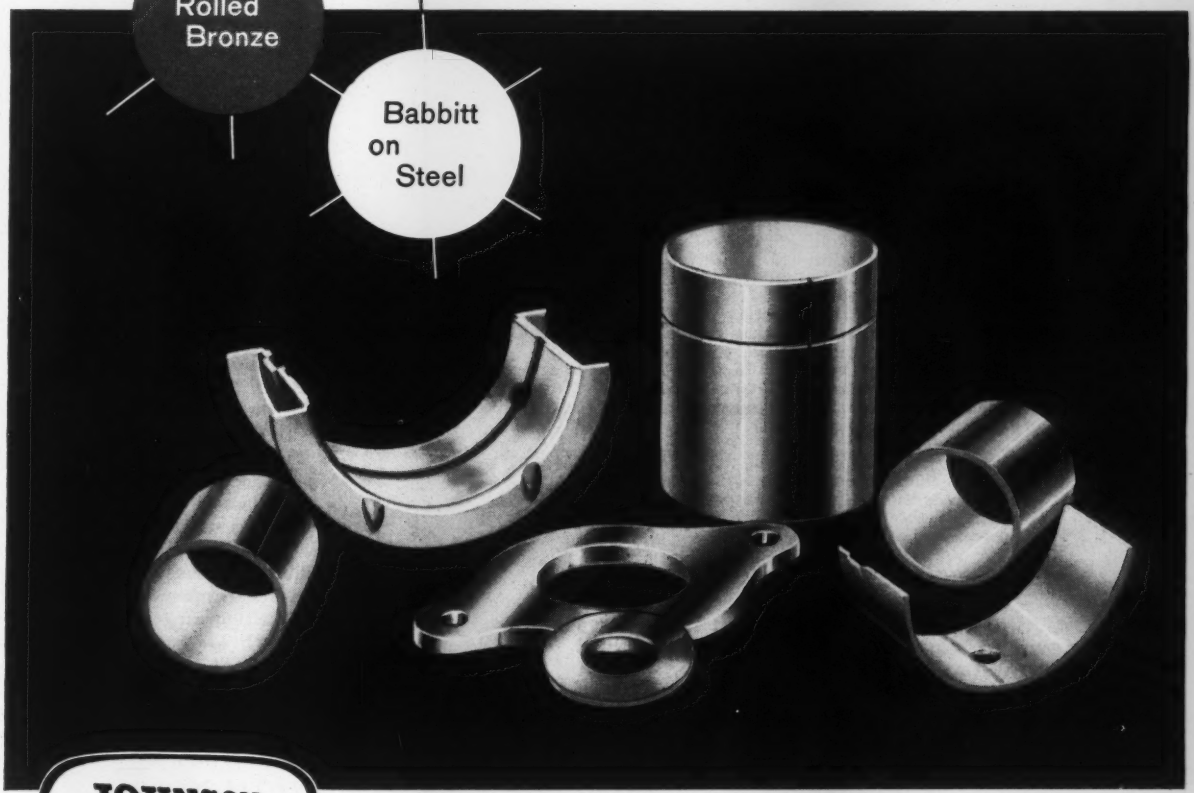
Rolled bronze, plain, graphited or ball-indented are available as either full round bushings, half bearings or washers. Furnished with any type of oil groove, slot or hole, these durable parts can be made to your specifications and produced in a large range of sizes. They have superior resistance to corrosion and wear.

Babbitt on steel is available for bushings or half bearings and thrust washers. Precision machined to close tolerance, these performance-proved products have a range of wall thicknesses suited to your needs.

Behind these quality products stands Johnson's more than 50 years' experience in the sleeve bearing and bushing field. Like thousands of others, you, too, can benefit from these quality products and Johnson's engineering help. Call, write or wire us for more information . . . for fast, reliable service.



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769 Mill Street, New Castle, Pa.

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They mean *better* stainless steel and super metals with uniform quality and gage, lustrous finish, and exceptional resistance to high heat, corrosion and wear. They mean *better* flexibility in the scheduling and delivery of strip to help you schedule *your* production more efficiently.

Our exceptionally rigid quality control—X-ray gaging for strip thickness, sensitive elongation gaging for rolling operations—and laboratory sampling of our strip before shipping, assure you stainless strip which is unsurpassed.

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a wide variety of industrial applications where strength and oxidation resistance at high temperatures are required.

A precipitation hardening alloy, A-286 can be solution annealed by heating to 1800 F and cooling rapidly. It can be precipitation hardened by reheating to 1325 F for 12 to 16 hr and air cooling. The tubing can be machined, bent, flared and spun in the same way as other austenitic alloy tubing. It can be readily welded by the shielded arc and inert-gas arc methods.

Synthetic Textile Fibers

United States Rubber Co., Royalene Dept., 10 Eagle St., Providence, R. I. has added three polyethylene textile fibers to its recently introduced line of synthetic textile fibers (see M/DE, May '59, p 174):

Type C—A heat and chemical resistant fiber especially compounded for shrinkage. It is used to provide unusual effects such as three-dimensional fabrics.

Type E—A very high shrinking fiber in boiling water.

Type L—An electrical-grade fiber.

Low Melting Glasses for Electronic Devices

A group of low melting glasses that can be evaporated and condensed as thin films on moisture sensitive devices have been developed by Bell Telephone Laboratories, 463 West St., New York 14.

The glasses, composed of varying proportions of sulfur or selenium and the heavy metals arsenic and thallium, become very fluid at temperatures between 260 and 660 F. This melting range is said to be 500 to 700 °F lower than that for any previously known low melting glass. In this range of temperatures (260-660 F) the glasses have viscosities approximately equal to that of castor oil at room temperature.

Properties and uses

The low melting glasses may replace some organic coating materials for encapsulating semiconducting devices, capacitors, resistors and printed circuit boards because they

SEE HOW TENSILES OF SPECIAL HB COMPARE WITH MUSIC WIRE

SIZE	STANDARD HB	SPECIAL HB	MUSIC WIRE
.1620	219,000 min.	**249,000 min.**	249,000 min.
.1350	227,000 "	**258,000 "**	258,000 "
.0800	244,000 "	**276,000 "**	282,000 "
.0200	310,000 "	**320,000 "**	350,000 "

—at savings of up to 60%

You can use PAGE *Special* HB for many jobs where music wire has always been specified —and save up to 60% on your wire costs! PAGE *Special* HB is a hard-drawn, high-carbon steel wire, available in diameters from .162" to .020" (bright finish). Its tensile strength approaches that of music wire in all sizes — and in sizes .090" and coarser equals it! Check the chart above for tensile strengths of four typical diameters. If you now use music wire, it makes sense to investigate PAGE *Special* HB; you may be able to reduce your wire costs considerably.

PAGE is a logical source for other types of manufacturers wire, too. Why not see for yourself what PAGE quality wire can do to improve your product and lower your costs. And if you have an unusual problem requiring a special wire PAGE can help you there, too. The latest example of PAGE leadership is the development of ACCO Aluminized Wire; commercially pure aluminum bonded to a steel core.

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WRITE FOR DETAILS

Booklet DH-107A gives complete data on PAGE *Special* HB, including table of tensile strengths, chemical composition, dimensions, finishes, and other information. Write us at Monessen, Pa., for your copy —or for information on any other PAGE wire.

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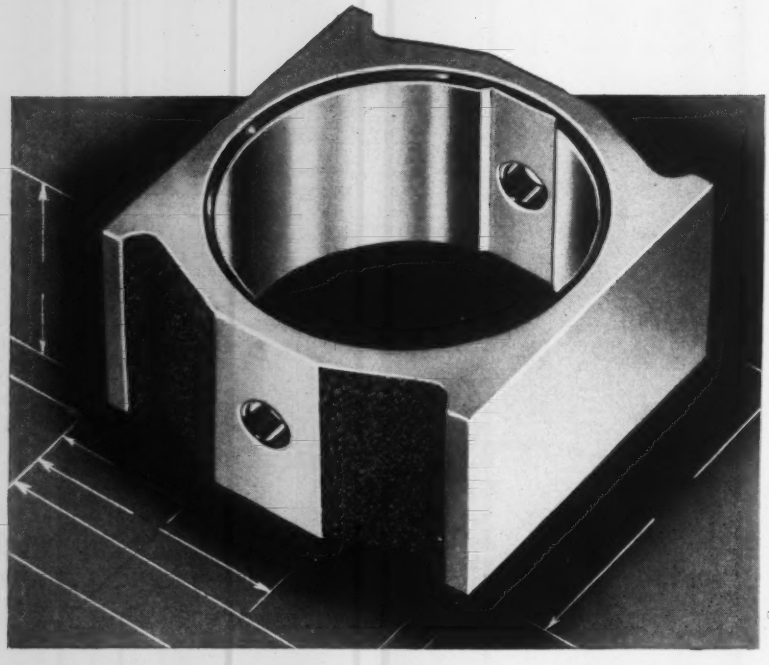
many difficult requirements...



We illustrate the cast bronze cam block for a hydraulic pump operating the hydraulic lift mechanism on an exceedingly well-known line of farm tractors.

The manufacturer of this equipment has very unusual specifications for this cam block. Its bore has a very fine finish specification. It also must be round and true to size within unusually close limits. In addition, it must be square to the face of the cam block within limits that ordinary methods of manufacture will not attain.

Bunting methods of manufacture result in a part which is completely to the customer's exacting specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered metal, or Alcoa aluminum, see Bunting first.

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What's new IN MATERIALS

have extremely low permeabilities to water and helium, and have good wetting characteristics with respect to most metals. The selenium compositions have good wetting characteristics with respect to ceramics and silicate glasses. According to the developer, these properties are not normally available in most organic coating materials.

The glasses range electrically from semiconductors to insulators with a minimum resistivity of 10^8 ohm-cm.

Chemically, the low melting glasses have the same durability as glasses in general. They are insoluble in water, dilute alkalis, acids including hydrofluoric, and organic solvents, but are attacked by concentrated alkalis. Several compositions are stable to air oxidation at temperatures above 480 F.

The glass compositions have a coefficient of thermal expansion ranging from 11 to 28 per °F and thermal conductivities averaging 0.17 Btu/hr/sq ft/°F/ft.

Alloy White Iron Is Tough, Wear Resistant

A new type of martensitic white iron containing chromium and molybdenum combines toughness with good wear resistance. The alloy shows promise for use in parts subject to wear such as sand pumps, chute liners and brick mold liners.

The new material, called 15-3 alloy, was developed by Climax Molybdenum Co., Div. of American Metal Climax, Inc., 500 5th Ave., New York 36.

Properties

Mechanical properties—As with all cast alloys, the mechanical properties of 15-3 alloy are influenced by such factors as section size, rate of solidification, rate of cooling after

MECHANICAL PROPERTIES OF ALLOY 15-3 SAND CASTINGS

Condition →	As Cast	Heat Treated
Transverse Str (18 in. span), in.	2900	2850
Deflection at Failure, in.	0.140	0.138
Rockwell Hardness	C55	C62
Toughness (breaking load × deflection)	406	393

THE DODGE STEEL ladle
BUSINESS MAGAZINE EDITION
PUBLISHED BY DODGE STEEL COMPANY
6501 Tacony Street, Philadelphia 35, Pa.

How to obtain better, more efficient parts with foundry engineered steel castings

As a designer or purchaser of steel castings, you should know about the unique engineering assistance available to you from Dodge. You may take advantage of our facilities in three ways: First, to assist you with the proper design and specification of a proposed new casting; Second, to review your present castings in order to determine how they may be redesigned to save metal and increase strength; Third, to help you in converting other metals and forms to steel castings. Here is a typical example of the effectiveness of this service:

REDESIGNED VALVE YOKE

By using the redesigned Dodge cast steel valve yoke shown in Figure 1 below, Yarnall-Waring Company, Philadelphia, Pa., realizes a total saving in material and machining time of $15.81 per unit. And this excludes savings in tool and handling costs!

Before adopting steel castings, Yarnall-Waring Company machined all units. The yoke posts were made of #4140 material, and after machining, were heat treated for greater tensile strength. The heat treatment caused warping of the body and scaling of the threads—which in turn, made assembly and alignment difficult.

NEW ONE PIECE YOKE

Now, by using Dodge cast steel one piece yokes, Yarnall-Waring stocks one item rather than four. They save time across the board—purchasing, production, storage, handling and record keeping.

The change in design can be readily seen. Threaded yoke posts and nuts are eliminated, and the stocking and purchasing of seven 1⅛" taps and chasers are no longer necessary.

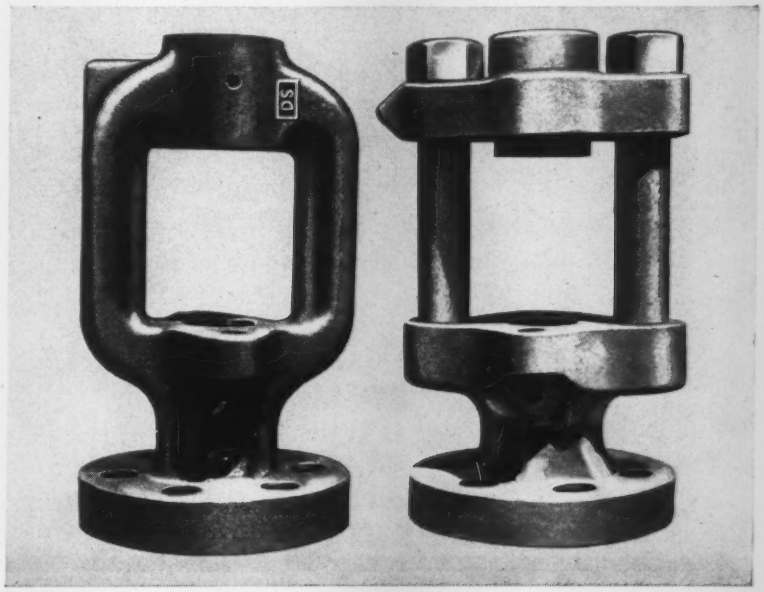
As for costs: material for the old style pillar-type yoke cost $17.58; material for the Dodge cast yoke, $8.32—a saving of $9.26! Machining time for the old style yoke cost $13.26, as compared to $6.71 for the Dodge Steel cast yoke—a saving of $6.55!

COMPLETE SERVICE

The best proof of the savings available to *your* company through the use of Dodge foundry engineering service is the experience of this manufacturer and others who have problems similar to yours. This timely and valuable service is ready to help you. May we study your problem?

Fig. 1 New Style

Fig. 2 Old Style



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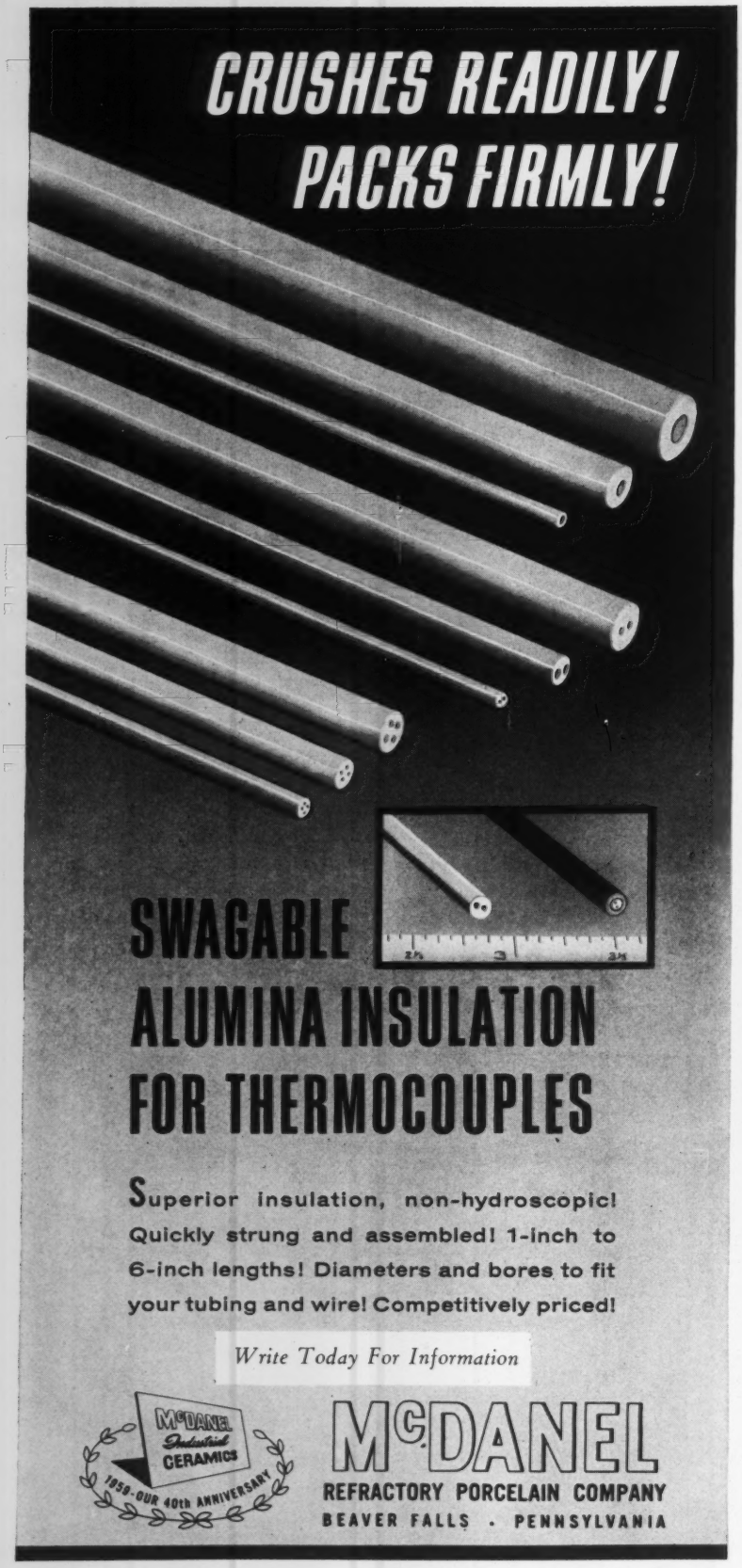
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What's new IN MATERIALS

COMPOSITION OF ALLOY 15-3 (%)

Carbon	3.00-4.00
Silicon	1.00 max
Manganese	0.50-0.90
Sulfur	0.06 max
Phosphorus	0.10 max
Chromium	12.00-18.00
Molybdenum	2.00-4.00

solidification or heat treatment, and specific carbon content. In general, a rapid rate of solidification obtained by low pouring temperatures, chill casting or light sections provides the optimum combination of mechanical properties. Strength and deflection properties of the alloy (see table) are appreciably better than those obtained with low alloy pearlitic or martensitic white irons.

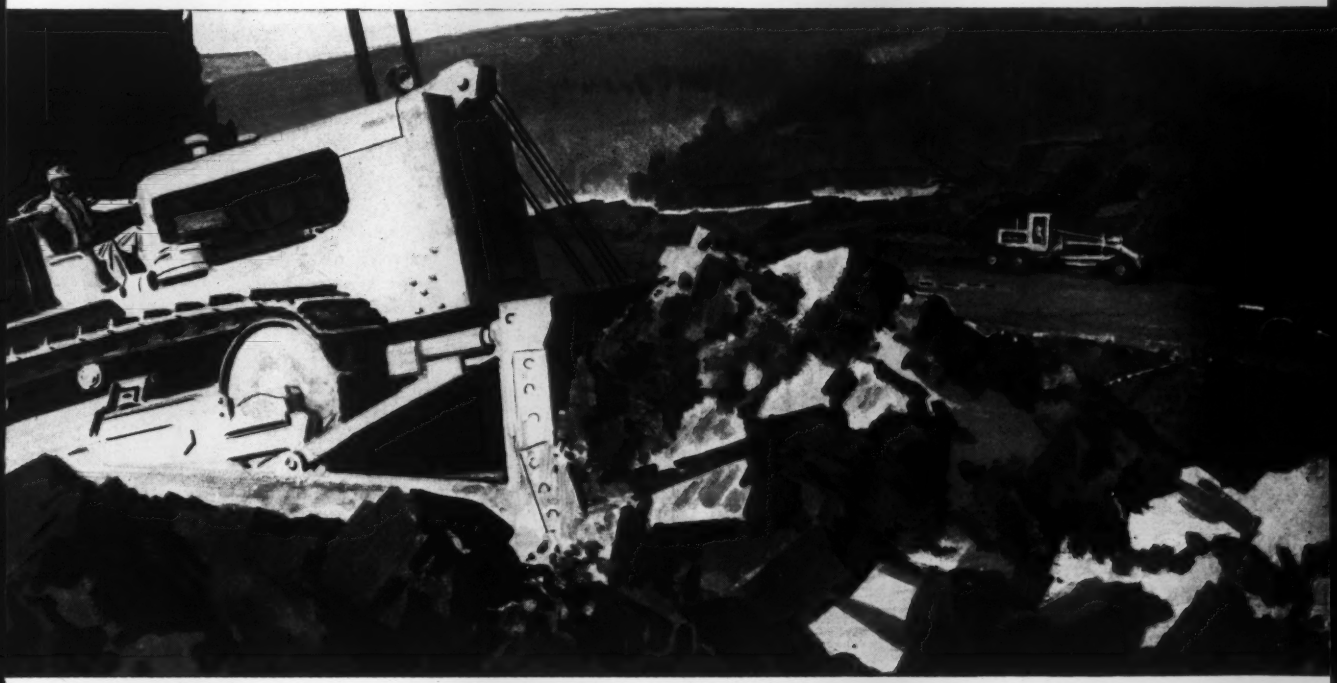
Wear resistance—Field tests show alloy 15-3 has better wear resistance than martensitic high chromium white iron, low chromium pearlitic white iron, austenitic manganese

Glass heat shield—A plate glass heat shield which reflects 65% of long wave infrared is being marketed by Corning Glass Works, Corning, N.Y. for the protection and comfort of personnel working in areas of intense heat. The window of tempered Pyrex glass is covered with a thin, transparent metallic film. The heat is said to literally bounce off the coating which is permanently bonded to the glass. The glass itself does not become hot. According to Corning, the shield can be used in foundries, metallurgical, power, glass and oven manufacturing plants, television and motion picture studios, and research laboratories. The shield is available in three standard sizes, 24 x 24, 24 x 36 and 24 x 48 in.

Earthmoving muscles from tubes of steel

A construction site springs to life as earthmoving equipment tugs, scoops, heaves and rips away at the earth's skin. It's grueling work!

That burly dozer. It's precision built! It's strong! Its massive blade can tear the side out of a hill. Yet, it's nimble, too. In spite of a crab-like figure, it can stop with a jolt, back off, spin, dig in and charge with the force of a galloping rhinoceros.



Power is jammed into these machines. That's why they're built with the toughest, most durable materials in the world. For years, leading manufacturers have chosen USS Shelby Seamless Mechanical Steel Tubing for hydraulic cylinders, tractor pins, bushings and more than 100 other vital parts in earthmoving, rockmoving, grading and all types of heavy mobile equipment. *Why?* Because Shelby Seamless Tubing is ideal for the fabrication of machine parts subject to bruising performance and long wear.

USS Shelby Seamless Mechanical Steel Tubing is another product from the world's largest manufacturer of tubular materials. For more than 80 years, National Tube has been foremost in building and industrial pipe applications. For more information, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

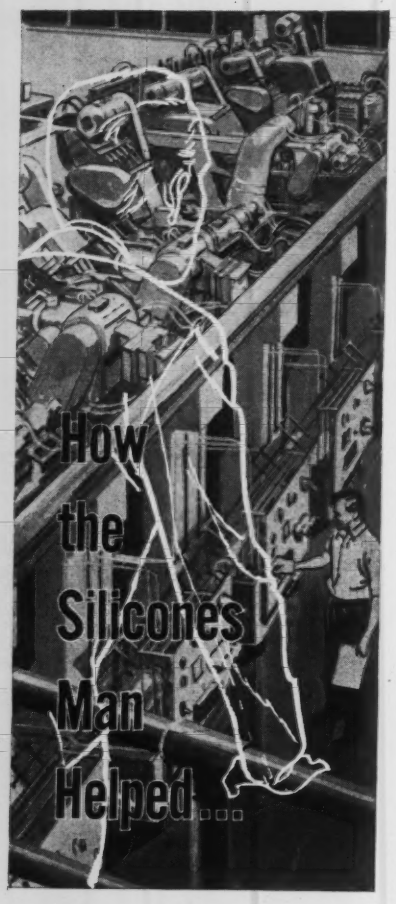
USS and Shelby are registered trademarks

USS

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors
United States Steel Supply Division
United States Steel Export Company, New York

For more information, turn to Reader Service card, circle No. 474



AQUEOUS EMULSION RELEASE FOR MOLDED SYNTHETIC RUBBER

The range of silicone release agents for molded products marketed by UNION CARBIDE has been further widened. Latest is a silicone oil-in-water emulsion with excellent compatibility for organic materials. This property of the new non-methyl emulsion is in the compatibility area between that of dimethyl silicone oils (very low) and that of organo-substituted silicones (high).

Outstanding among the features of the silicone emulsion are its inertness and ease of removal (any common solvent can be used) from mold and product. These advantages permit use of the emulsion in reactive systems without risk of harmful side effects, and eliminate the difficulties of subsequent painting or labeling. The silicone emulsion itself is nonionic, stable, no more corrosive than water, and has a pleasant odor.

Manufacturers of automobile mats and home floor tiles have discovered that the silicone emulsion speeds production and gives a clean product. In emulsion-type waxes and polishes, the emulsion is added in trace amounts to increase mar and scuff resistance.

LOW-HEAT CURE FOR HIGH-HEAT VARNISH

A new silicone varnish, developed by UNION CARBIDE, requires only relatively low curing temperatures in ordinary ovens and regular drying equipment. Baking ovens capable of 275° F. or higher temperatures can be utilized, following routine procedures for varnish dip and bake.

The new silicone dipping varnish is approved for electrical insulation, Class H applications—as in transformer coils, motors, generators, and other equipment. It is equally effective for high temperature and/or heavy duty, continuous service, in large or small apparatus.

Silicone varnish with low temperature curing properties provides a nontacky surface with less weight loss than other silicone varnishes. It gives high build and gloss, with good impregnating and bonding.

In addition to heat resistance, the new varnish is resistant to humid and corrosive atmospheres – important causes of insulation failure. No additional water repellents or chemical-resistant coatings are needed to obtain full protection.

PREVENTING SURFACE OXIDATION OF MOLTEN METALS

A high-boiling silicone oil, floated on the surface of molten metal used to heat-treat nylon cords and yarns, is helping British textile processors to prevent atmospheric oxidation of the metal bath. The temperature of the metallic mixture ranges from 160 to 240° C., and the method has been patented.

This is a practical example of the heat-resistance of films formed by silicone oils.

The Silicones Man is accustomed to helping solve problems like these ... and he may be able to help you, too. For background information on these and other applications, write Dept. GM-0903, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE TRADE-MARK **SILICONES**

The term "Union Carbide" is a registered trade-mark of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 412

What's new IN MATERIALS

steel and pearlitic low carbon unalloyed steel.

Fabrication

Machining — Electro-erosive machining methods are recommended for castings made of alloy 15-3. If conventional machining methods are used, carbon content should be kept at 2.5 to 3%. At this level, castings can be annealed to permit machining with carbide tools.

Welding, cutting—Extensive welding of this alloy is not recommended. Small casting defects can be repaired by using rods made of alloy 15-3 or a high chromium iron. The alloy can be cut by powder cutting methods or with a carbon arc. Torch cutting with the normal oxyacetylene flame is not recommended.

Heat treatment

Heat treatment consists of heating alloy 15-3 castings slowly to 1750-1950 F, holding 1 hr per in. of thickness, and cooling in still or moderately moving air. The castings are then stress relieved at 400-500 F.

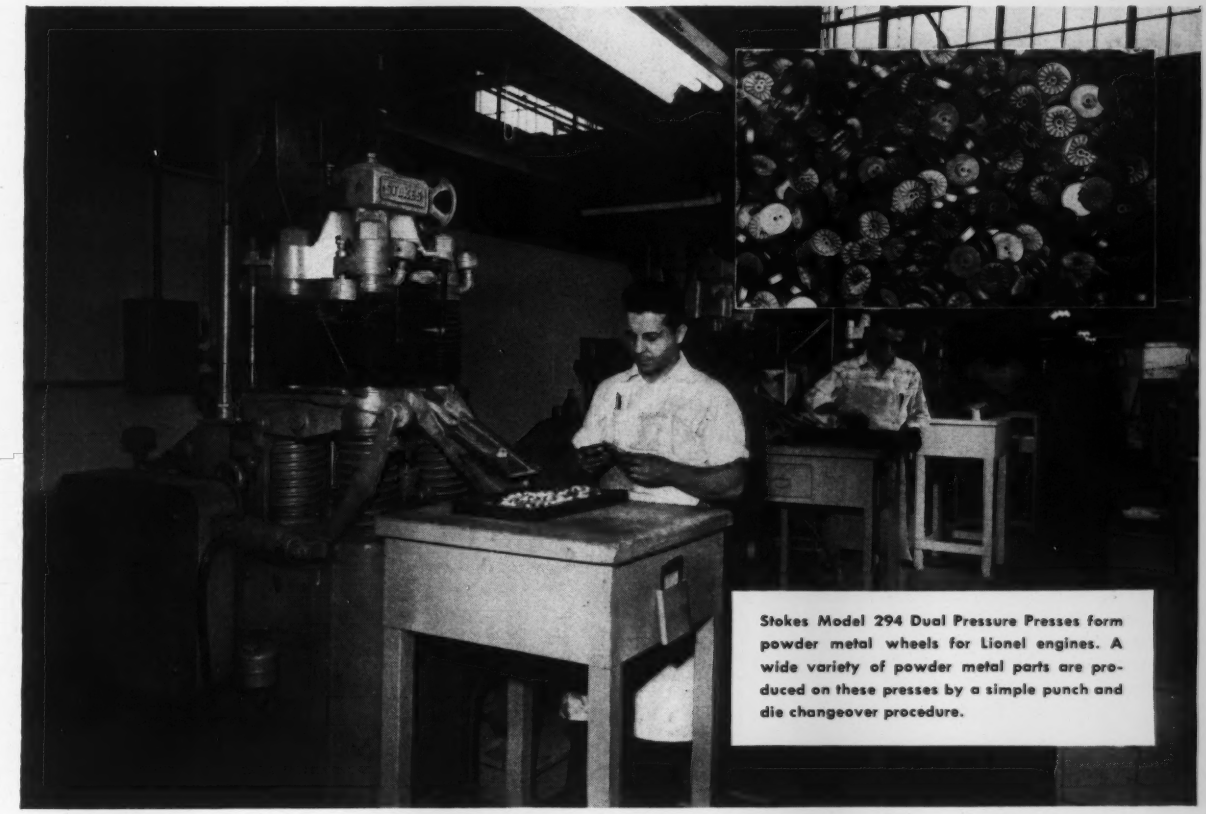
Type 11 Nylon Resins Available in U. S.

Belding Corticelli Industries, 1407 Broadway, New York 18 has recently completed an agreement with Organico S. A. of France to market Type 11 nylon resins in the United States. Previously, the resins were available to a limited degree through a U. S. distributor.

Type 11 nylon resins, which are derived from the castor bean, have received wide acceptance in Europe

PROPERTIES OF TYPE 11 NYLON

PHYSICAL PROPERTIES	
Specific Gravity	1.045
Specific Heat, Btu/lb/°F	0.58
Melting Point, F	367
Water Absorption, %	0.4
MECHANICAL PROPERTIES	
Tensile Strength, psi	8500
Elongation, %	120
Modulus of Elasticity, psi	178,000
Impact Strength (Izod notched), ft-lb/in.	3.3
Rockwell Hardness	A55
ELECTRICAL PROPERTIES	
Dielectric Strength, v/mil	425
Volume Resistivity, ohm-cm	2×10^{13}
Dielectric Constant (10^3 cycles)	3.3
Power Factor (60 cycles)	0.03



Stokes Model 294 Dual Pressure Presses form powder metal wheels for Lionel engines. A wide variety of powder metal parts are produced on these presses by a simple punch and die changeover procedure.

Stokes precision presses help Lionel model trains run on powder metal wheels

The name Lionel is synonymous with enjoyment to boys of every age. Since 1900, Lionel has manufactured hundreds of thousands of model train sets. In an effort to increase quality and reverse rising cost trends, Lionel purchased a battery of Stokes Powder Metal Presses several years ago to form many of the trains' parts. Today, over ½ million parts are produced each day on Stokes precision presses.

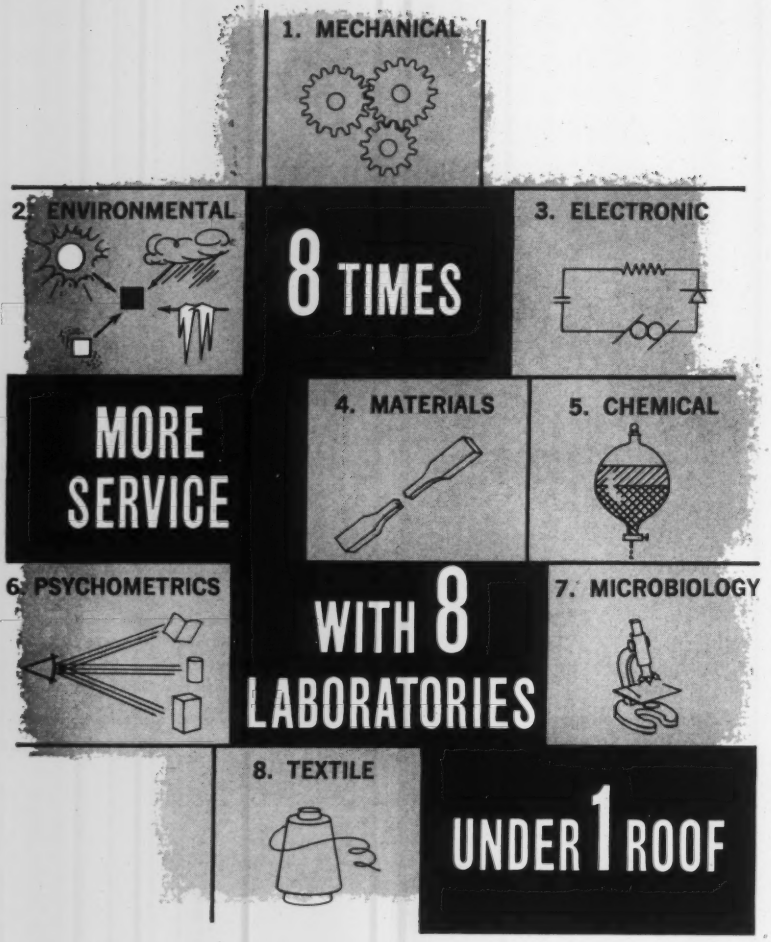
For example, Stokes presses form iron car wheels from powder metal. Unlike machine punched wheels, powder metal wheels are heavier. They lower the train's center of gravity and give it added stability. Finished wheels are more uniform and realistic. What's more, powder metallurgy has reduced wheel costs over 40%.

Perhaps powder metallurgy can cut your costs and save metal over conventional machining methods. It can aid you in getting properties of metals, alloys and mixtures unobtainable through other methods. And Stokes can help you determine production costs . . . handle complete laboratory production for sampling . . . include design and fabrication of punches and dies . . . and recommend types of equipment. Why not look into it further. Give Stokes a call . . . today.

Tabletting Division
F. J. STOKES CORPORATION
5500 Tabor Road, Philadelphia 20, Pa.

STOKES

For more information, turn to Reader Service card, circle No. 399



Whether it's a routine control analysis of an alloy, an environmental test of a "black box", or a complete structural and operating evaluation...whether it's appliances or batteries or turbines or valves...you get more from the **integrated laboratories** of United States Testing Company. Multi-million dollar facilities...career test engineers...a wealth of experience in your field...all these save you costly investment in laboratory equipment and give you top-quality testing and R/D services. Check *your* needs against the facilities and services available.

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For more information, turn to Reader Service Card, circle No. 396

What's new IN MATERIALS

for several years. Belding Corticelli hopes eventually to start domestic production of these resins.

Outstanding characteristics of Type 11 nylon resins are:

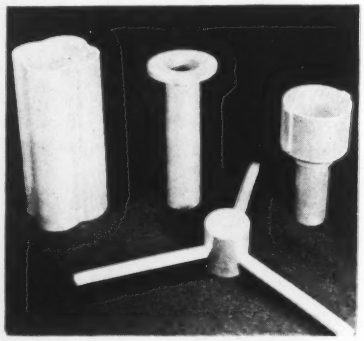
1. Low moisture absorption.
2. Good electrical properties.
3. Good molding properties.
4. Ability to be formed into large parts such as complete sink units.

Aluminum Extruded by New Impact Technique

Complex aluminum shapes such as faucet handles and the hub and spokes of a steering wheel are being turned out by a new extrusion technique called lateral impact extrusion. The process was developed by Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19.

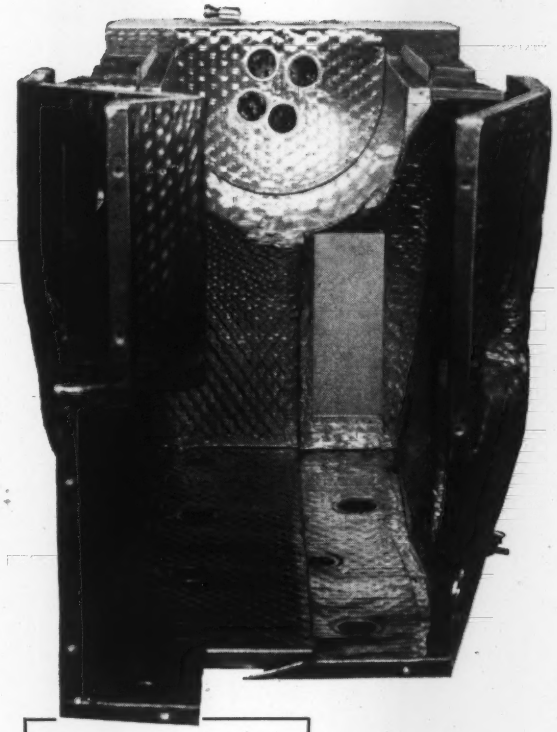
In lateral impact extrusion, metal flows outward from the direction of the press stroke in addition to forward and reverse flow. The new impact process essentially combines forging and extrusion to produce intricate products with close tolerances. Heretofore, aluminum impact extrusions were made by reverse impact (metal flow up around a punch), forward impact (metal flow down into a die), and combination impact (metal flow both upward and around the punch and down into the die).

The lateral impact process permits economical production of parts that combine an intricate hub, or core, with such lateral extensions as spokes or vanes. Such parts, it is



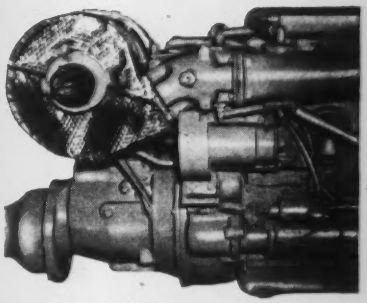
***Spoked wheel** made by lateral impact extrusion is shown surrounded by conventional impact extrusions.*

Johns-Manville PRE-KLAD insulations are made possible through the company's extensive experience in fabrication and forming of thin foils.



This typical PRE-KLAD insulated housing features combination of molded parts, strengthened channel construction, close tolerance cut-outs to accommodate fittings and attachments.

Now—insulate difficult shapes in one fast operation . . .



PRE-KLAD as used by diesel engine manufacturers. Here, J-M engineers worked with customer's engineers to develop insulated blankets that readily slip over turbochargers to protect personnel and keep engine room temperature down.

Among the many PRE-KLAD applications

- Gasoline Engines
- Gas Turbine Engines
- Steam Turbines
- Heated Mechanical Equipment
- Domestic and Industrial Furnaces
- Stress Relieving Blankets
- Ingot Pads
- Heated Laboratory Equipment
- Diesel Engines, Manifolds, Turbochargers
- Home Incinerators, and other Hot Appliances
- Portable Heat Retention Equipment
- Turbogenerators
- Materials Handling Equipment
- Gear Housings
- Removable Casting and Forging Covers
- Furnace Nozzle Cones

with Johns-Manville PRE-KLAD Insulation!

New refractory fiber insulation is factory sheathed in heat-resistant foils to any required shape . . . temperatures to 2000F!

In new PRE-KLAD insulation, designers have an insulation that's right in step with efficient assembly line methods. For PRE-KLAD components arrive at your plant ready to install . . . in one fast operation!

Originally developed for jet aircraft . . . PRE-KLAD insulations are precision engineered to solve individual heat retention problems. Johns-Manville tool engineers create the special molds and dies to form the stainless steel or other thin foils into the shape you require. Then, refractory felt insulation is expertly sandwiched between inner and outer foil jackets, which are then spot- or seam-welded into a ready-to-install housing or blanket. The result is an insulating component that can be used wherever a strong, lightweight foil-protected insulation is indicated.

The insulation in PRE-KLAD is Johns-Manville CERAFELT® . . . a refractory fiber insulation that is produced by converting molten refractory materials into a mass of uniform ceramic fibers. The fine CERAFELT fibers are then felted with a minimum of binder to form an insulating material that combines lightness, heat resistance and an extremely low *k* factor.

Write today for the informative new brochure on PRE-KLAD insulations.
Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ont.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

For more information, turn to Reader Service card, circle No. 394

Stalwart Announces

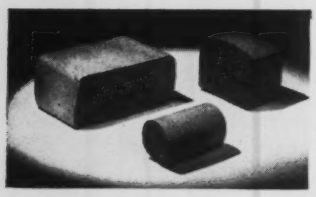
SILICONE SPONGE RUBBER...

in extruded and calendered shapes

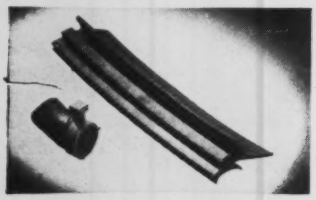
Exclusive new processes produce cross sections, lengths and densities to your specifications

Here is important news for designers in the appliance, aircraft, electronics and other industries! A unique process developed by The Stalwart Rubber Company now enables silicone rubber to be extruded and sponged in complex configurations or calendered to close tolerances to meet customer specifications. Here are the facts . . . Stalwart extrudes silicone sponge parts in 1/16 to 8-inch dimensions in lengths up to 300 feet. Calendered sheets are produced in widths up to 36 inches. These silicone sponge parts resist sunlight, ozone, and aging as well as temperatures ranging from −160° to +500° F. Stalwart also mass-produces all types of precision parts from natural and synthetic rubbers.

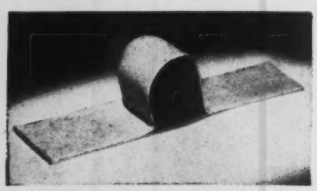
8302-SR



Cell sizes range from very coarse to fine with open or closed cell-structures.



Silicone sponge extrusions can be combined with solid silicone rubber extrusions.



Calendered and extruded silicone sponge shapes can be covered with heat-resistant fabric.

Send today for your copy of the new Stalwart Catalog.

Another first by

STALWART RUBBER COMPANY

165 NORTHFIELD ROAD • BEDFORD, OHIO

PLANTS in BEDFORD, OHIO and JASPER, GEORGIA.

For more information, turn to Reader Service card, circle No. 386

What's new IN MATERIALS

claimed, would be free of porosity and brittleness, and thus have toughness and high strength.

Other News . . .

Metals

▸ Aluminum spheres (99.99% pure) are now available in production quantities from Accurate Specialties Co., Inc., 37-11 57th St., Woodside 77, N. Y. The spheres, used in producing alloy junctions in semiconductor devices, are supplied in sizes from 0.004 to 0.125 in. in dia.

▸ Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 46, Wis., has added extruded rectangles to its line of cast and rolled copper alloy wear strip materials. The rectangles are supplied in 46 sizes.

▸ Internal radiant heat transfer has been investigated at the National Bureau of Standards, Dept. of Commerce, Washington 25, D. C. as a mechanism for relieving thermal stress in type 302 stainless steel box beams. The study showed that significant relief may be obtained through maximum internal radiant transfer, a condition that can be achieved by blackening the internal surfaces of the structure. Designing aircraft beam structures to accomplish this effect should lead to savings in weight, according to NBS.

Nonmetallics

▸ Extrusions and fabricated parts made from Du Pont's Delrin thermoplastic resin are now available in the form of strip, rod, tubing and special shapes from National Vulcanized Fibre Co., 1059 Beech St., Wilmington 99, Del.

▸ A glass-TFE electrical insulating material for high temperature applications is now available as copper-clad sheet and as rod, tubes and flat sheets from Rogers Corp., Rogers, Conn. The new material is called Duroid 5870.

▸ A high temperature graphite has been developed for use as a bearing material in parts operating at temperatures up to 1200 F. The material, known as Grade 469, has good wear resistance and is resistant to most chemicals and gases. It is available from Stackpole Carbon Co., St. Marys, Pa.

▸ A series of glass-reinforced molding compounds are available from

BARBER COLMAN

Founded in 1900 for the purpose of building textile machinery, Barber-Colman Company today produces diversified equipment and products for such fields as automotive, aviation, machine tool construction and textile.

Versatile ACIPCO

centrifugally spun TUBES

. . . for super speed warpers

Barber-Colman Company, Rockford, Illinois, manufactures more than 85% of the section beam warpers produced in the world. And Barber-Colman specifies ACIPCO Centrifugally Spun Cast Iron Tubes as supplied through our mid-west distributor, C. A. ROBERTS CO.

The Super Speed Warpers produced by Barber-Colman have a winding speed of 900 yards per minute yet these units are also engineered for low and uniform tension to produce a beam in which thread ends are stressed alike.

Specifications for the machines are strict: tubular metal parts must be machined to a fine finish and to precise measurements. They must have high strength and be balanced so that they are capable of withstanding sustained high speeds. ACIPCO tubes **custom-fit** requirements such as these.

Centrifugally Spun ACIPCO tubes have a dense, non-directional grain structure which is easier to machine. Important, too, their **inherent** dimensional stability and concentricity makes dynamic balance easier to attain in finished products.

If your machines or products employ tubes of stainless steel, carbon steels, alloy irons, or special analyses as components, it will pay you to investigate ACIPCO. Call or write for complete information on ACIPCO tube applications in your field. No obligation, of course.

SIZE RANGE: Lengths up to 410″ have been produced to meet modern machinery requirements. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special analyses.

FINISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

SPECIAL PRODUCTS DIVISION

AMERICAN CAST IRON PIPE CO.

BIRMINGHAM 2, ALABAMA

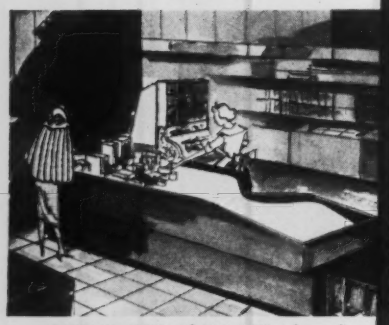
ACIPCO

For more information, turn to Reader Service Card, circle No. 465

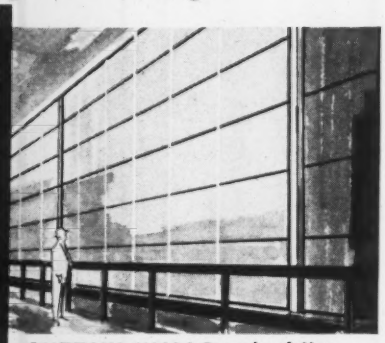
When wear creates problems...

MET-L-WOOD®

puts beauty to stay!



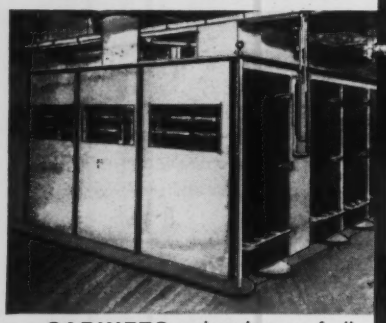
COUNTERS of Met-L-Wood can be designed to fit any decorating scheme, yet stand hardest service.



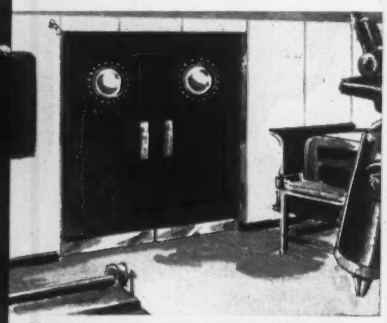
CURTAIN WALLS made of Met-L-Wood panels permit *fast* construction; lend beauty and life to buildings.

MOTOR STAIRWAY and WALKWAY PANELS of Met-L-Wood stand up under constant use... help damp vibration, resist denting.

WAINSCOTING *in traffic areas gets rough treatment;* is a natural for decorative Met-L-Wood use: sustained beauty without upkeep.



CABINETS and enclosures of all kinds gain strength, beauty, life from Met-L-Wood.



X-RAY & RADIATION ROOMS can be attractive as well as safe with lead-cored Met-L-Wood panels, doors.

Detailed data on how Met-L-Wood can serve you, in one or more of its many forms, is yours for the asking. Write for new Bulletin 522. Met-L-Wood Corporation, 6755 West 65th Street, Chicago 38, Illinois.

STRONG
DURABLE
LIGHTWEIGHT

MET-L-WOOD Metal bonded to plywood

For more information, turn to Reader Service card, circle No. 476

What's new IN MATERIALS

Coast Mfg. & Supply Co., P. O. Box 71, Livermore, Calif. The molding compounds are available in the following resin systems: phenolic, epoxy, silicone and polyester.

▸ An extremely soft neoprene rubber compound, available in three different Durometer hardnesses is said to outperform sponge rubber in many applications. The compound was developed by Mechanical Rubber Products Co., Warwick, N. Y.

Finishes

▸ Ionics, Inc., 152 6th St., Cambridge 42, Mass. has developed a new anode material called Tirrelloy. Designed for use in aqueous electrolysis systems, the material also shows promise as an anode in conjunction with impressed current cathodic protection systems, or to increase the corrosion resistance of titanium, columbium and tantalum.

▸ A general purpose alkyd enamel has been developed by Glidden Co., 11004 Madison Ave., Cleveland 2, Ohio for use on wood and metal. The paint, called Speedenamel, can be used indoors or outdoors.

▸ Allied Research Products, Inc., 4004 E. Monument St., Baltimore, Md. has introduced a gold dye for application over clear chromate conversion coatings. The dye, called Iridite GO-1, can be applied over coated refrigerator shelves, wire goods and tubing.

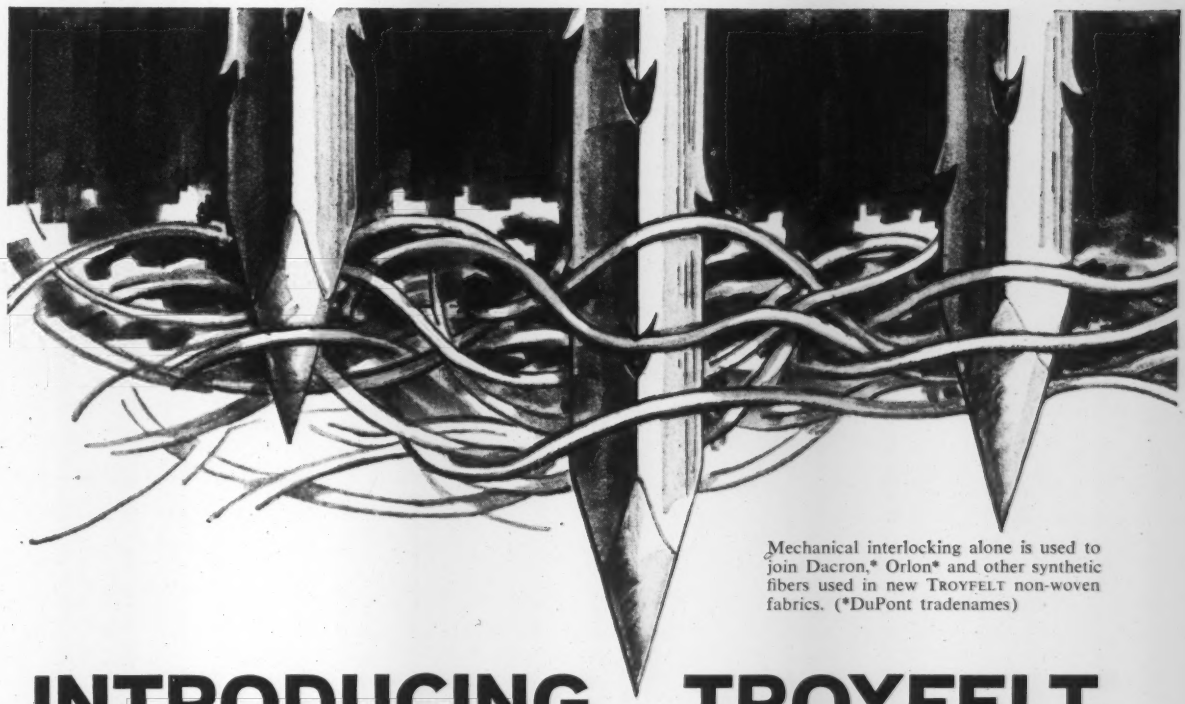
Joining materials

▸ A new process of gas-shielded metal arc welding called Dip Transfer has been developed by Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 150 E. 42nd St., New York 17. Metal is transferred by a wiping action rather than by an arc stream.

▸ Java Latex & Chemical Corp., 1713 West Farms Rd., New York City has introduced an adhesive called Polytex for bonding burlap and other fabrics to polyethylene.

Testing equipment

▸ Thwing-Albert Instrument Co., Penn St. at Pulaski Ave., Philadelphia 44 is now producing a heavy duty torsion tear tester to measure tearing strength of strongly directional materials which tend to tear at an angle from the application of force. The tester holds the specimen rigidly throughout its entire length on both sides, and the tearing force is directed to produce a tear down the center line of the specimen.



Mechanical interlocking alone is used to join Dacron,* Orlon* and other synthetic fibers used in new TROYFELT non-woven fabrics. (*DuPont tradenames)

INTRODUCING TROYFELT

a versatile new family of synthetic felts made without chemical binders

Where can you use these amazing new felts? Field-tested and proved for more than two years, these are typical reports:

A FILTER MAKER reports TROYFELT outperforming wool felts 7 to 1 in filtering highly abrasive Taconite ore.

AN ELECTRONICS firm finds TROYFELT a superior packing because it stays resilient at high and low temperatures.

A CUTLERY MAKER uses TROYFELT to polish stainless ware . . . finds its smooth surface gives higher luster, lasts longer.

. . . window makers use it as an impervious life-time seal . . . shoe makers because it lasts longer as a padding . . . gasket makers because it die cuts without ravelling . . . it's also used as wadding in cartridges . . . as a vibration isolator.

WHAT IS TROYFELT?

. . . basically, TROYFELT is a non-woven synthetic felt. It is available in Dacron, in Orlon, and in other synthetics. Unlike other non-wovens it has no chemical binders . . . the individual fibers are joined mechanically. Thus it is a softer material, a better insulator, a better filter, a better packing, padding and wick.

And yet TROYFELT *offers all the long-lived properties of the synthetics: a marked resistance to chemical attack, heat, abrasion and wear!*

Want *all* the facts? Just circle the number below on this magazine's handy reply card.

TROYFELT *. . . by the pioneers in non-woven synthetic felts*

INDUSTRIAL PRODUCTS DIVISION • TROY BLANKET MILLS

200 Madison Avenue • New York 16, New York

For more information, turn to Reader Service card, circle No. 423

"Here's a boxful of cost-cutting, product-improving ideas for you"

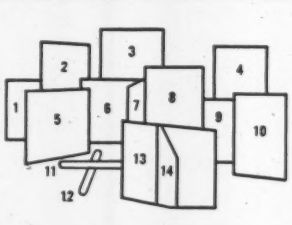
In versatility, performance and cost, Vulcanized Fibre may help crack your next design problem

For proof, look at this National product and its almost unbelievable range of uses. To name a few: delicate surgical instruments; rail joint insulation for railroads; clothes hampers for the home; dense, durable gears and cams; flexible backings for abrasive disks; arc chutes for lightning arrestors; motor insulation; punched tape for data processing machines; formed athletic guard equipment.

Among engineering materials you'll find National Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has unsurpassed arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden and repeated shock and impact without failure. And it is available in a fire resistant grade.

After 100 years, users are still finding new things they can do *to* Vulcanized Fibre. It can be machined, polished, painted, embossed, lacquered and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper. It can even be formed or deep drawn into intricate shapes. Available in both standard and special forms and sizes.

Send for our special kit of samples (shown above)—write on your letterhead please—and evaluate the design possibilities personally. Let us know what use you have in mind. We'd like to help. National Vulcanized Fibre Co., Dept. KK-7, Wilmington 99, Delaware.



1. "Peerless" Electrical Insulation. 2. Embossed, vinyl finish. 3. Corrugated "Peerless" .010. 4. Fibre and "Mylar." 5. Cold embossed. 6. Fibre-Copper, two-sides copper. 7. Black Commercial. 8. Fibre-Laminated Plastic, two-sides fibre. 9. Red Commercial. 10. Corrugated. 11. Rod. 12. Tube. 13. White. 14. Fibre Armored Plywood.

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Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, "Teflon" or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon: 2 grades; rod, strip, pressure tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

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MATERIALS AT WORK

Typical honeycomb panel *consists of thin sheets of ceramic oxide bonded to ceramic oxide honeycomb core.*

Honeycomb—cont'd from p 12

Boeing, ceramic honeycomb structures are light and strong; they resist temperatures of 3000 F and higher; they stand up against rain erosion; and they can be economically mass produced in many shapes.

The ceramic structures, which are similar to metal or plastic honeycomb sandwich structures, consist of thin skins and thin corrugations of high strength, high temperature resistant ceramics. Most of the structures are made of sintered alumina; however, spinel, mullite and fused silica are also being used.

To make the structures, pure oxide materials are finely ground and combined with organic binders and either organic or inorganic liquids to form a paste. The paste is then rolled under heat into thin, dense sheets which are flexible enough to allow sharp bends (see photo above). The formed components are then bonded (with a thin mixture of the same material) and fired.

Other types of ceramic honeycomb sandwich structures currently being used for leading edges, nose cones and skins of supersonic craft include: bonded ceramic fibers; and metal skins brazed to a flame-sprayed ceramic core. Under development are honeycomb panels made with aluminum oxide and zirconium oxide for service at 2500 and 3500 F respectively, and honeycomb panels made with hafnium and thorium oxide for service at 4000-5000 F.

Paste-like *ceramic material is rolled into thin, dense skin.*

Metal Powder Tools Cut Vibration

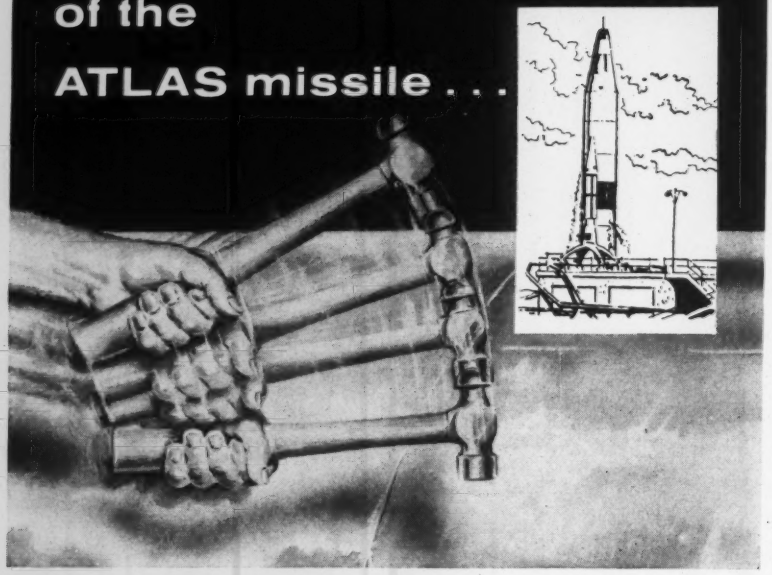
by Horace Frommelt, *Director, Spring Garden Institute, Metal Cutting Center*

The excellent damping capacity and relative low cost of copper-infiltrated iron powder parts are being used to good advantage in the design of cutting tools. The use of powder metallurgy for boring bars, shanks, milling cutter bodies, etc. results in 1) longer operating life, 2) better surfaces, 3) closer tolerances and 4) faster cutting speeds. Primary reason for these advantages is the substantial reduction of vibrations.

Problem of vibration

It is well known that vibration of tools in the machining of metals causes reduced tool life, inaccuracy and poor surfaces. There are two types of vibrations: forced and self-induced. Forced vibrations result from the mechanical operation of pushing the cutting tool against a

How an ordinary hammer proved the case of the ATLAS missile . . .



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered*, for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

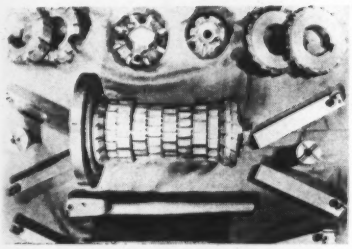
This stainless steel skin material, supplied by Washington Steel, required extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

Stainless Steel—the Space Age Metal

Washington Steel Corporation
7-F Woodland Avenue
Washington, Pa.

For more information, turn to Reader Service card, circle No. 466

MATERIALS AT WORK



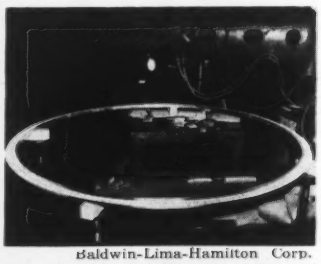
Copper-impregnated iron powder *is used for bodies and shanks of a variety of cutting tools.*

workpiece. The frequency of these vibrations depends upon the mechanical source. Self-induced vibrations, the more troublesome of the two, are self-perpetuating and depend upon the nature of the material composing the shank and the forces inherent in the cutting operation.

Heavy metals considered

In order to prevent, or reduce, harmful self-induced vibrations, designers have been specifying materials with a high modulus of elasticity, such as solid carbide or the so-called heavy metals. This solution is justified because the higher the modulus, the lower the ratio of stress to strain, and hence the lower the tendency on the part of the cutting forces to distort or displace the tool. However, these materials are too expensive to be practical.

The search for low cost materials



Baldwin-Lima-Hamilton Corp.

Largest aluminum ring—Shown above is what is claimed to be the largest aluminum ring ever rolled. Used for ball separation, the ring is 1½ in. thick, and has a 111½-in. o.d. and a 103½-in. i.d. It has 160 drilled and reamed holes which hold and separate individual balls. The alloy used is 6061-T6.

COATING	FABRIC SUBSTRATES				
	COTTON	NYLON	"DACRON"*	GLASS	"TEFLON"*
NEOPRENE	●	●		●	
BUNA-N	●	●		●	
"FO"†	●	●			
BUTYL	●	●			
"HYPALON"*		●	●	●	
ACRYLIC			●	●	
SILICONE			●	●	●
"VITON"*			●	●	●

*Registered Du Pont trademark
†A Du Pont trade name

At Du Pont special coatings are combined with selected fabrics to produce "Fairprene" having the advantages of both. Tabulated above are many of the combinations possible. Fabric can have balanced coating on each side; can have one side bare; or more or less heavily coated than the other; or a different coating on each side. "Fairprene" can have more than one layer of fabric enclosed or can have compound between layers of fabric. Thus "Fairprene" is remarkably versatile material tailor-made for an extraordinary range of applications.

These elastomer-fabric combinations of Fairprene® form design materials of marvelous versatility

● Exciting new design materials with an outstanding range of capabilities are created by the exclusive calendering-coating process that forms "Fairprene". Using this process, Du Pont creates many materials from elastomer and fabric with many variations in their chemical and physical properties. Du Pont engineers are eager to help you evaluate "Fairprene" for designing new products or improving present ones. Mail the coupon or write E. I. du Pont de Nemours & Co. (Inc.), Fabrics Division MDE-97, Wilmington 98, Delaware, for complete information.

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- Foundation Blankets
- Gaskets
- Gouge Strips
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- Meter Bellows
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- Missile Blast-Deflection Curtains
- Modulator Diaphragms
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- Protective Clothing
- Pump Cups
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- Radar Antenna
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- Regulator Diaphragms
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- Vacuum Device Diaphragms
- Vacuum Molding Bags
- Water Bags

**"Fairprene" is Du Pont's registered trademark for its coated fabrics, sheet stocks and cements.

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Fabrics Division MDE-97, Wilmington 98, Delaware

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with good damping characteristics led to plastics. Although epoxy proved quite useful from the point of view of vibration damping, it was discarded because it could not withstand high temperatures. Epoxy-bonded iron powder parts were better, but not good enough for the same reason.

Powder metallurgy selected

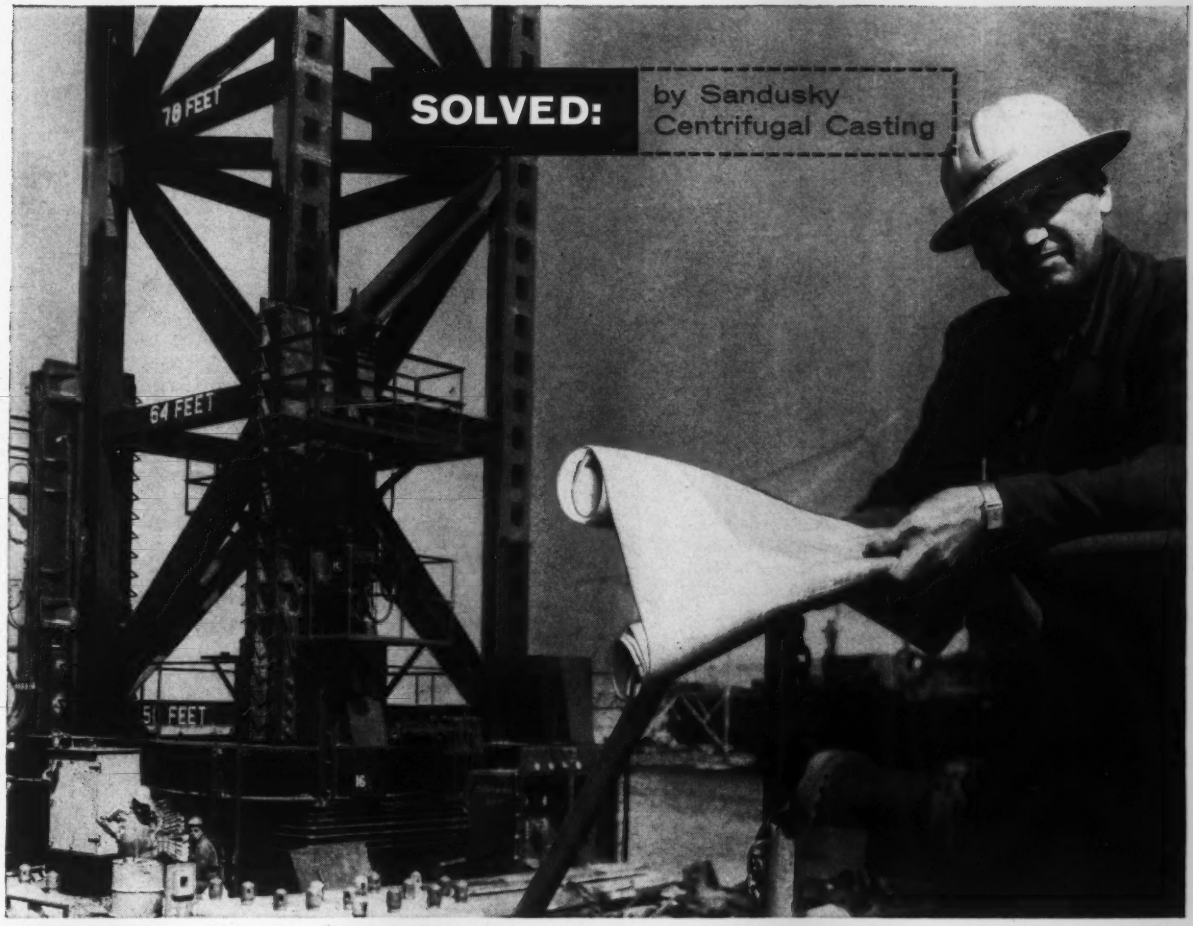
Shown in the accompanying photo are a variety of cutting tools made with copper-impregnated iron powder bodies and shanks. The carbide or ceramic cutting elements are inserted in slots formed during the briquetting phase and are locked firmly and securely in place by the shrinkage that takes place during the sintering and infiltrating phase. Tensile strength of these parts is in the neighborhood of 70,000-80,000 psi. It is possible, however, to heat treat the parts to tensile strengths as high as 120,000-140,000 psi.

Investigations conducted over the last four years indicate that the metal powder parts solve most of the vibration problems discussed above. On the average, vibration in powder metal shanks is about 50% less than it is in identical steel shanks. The excellent damping effect is due to the fact that the iron particles are held in a matrix of copper.

The use of powder metallurgy for tooling has made possible certain operations that were either previously impossible or extremely time consuming. For example, a 4140 steel sleeve heat treated to Rockwell C 50 was successfully bored in less than one minute with ceramic cutting elements set in a powder metal boring bar. It previously required two hours to grind—and the finish was inferior.

Epoxy-Backed Electro Reduces Weight 70%

Epoxy resin is the key to the development of what is termed the first successful plastic-backed electrotypes for letterpress printing. According to Shell Chemical Corp., chief advantages of the new electrotypes are: 1) low weight (about 60-70% less than lead electros), and 2) no finishing is required other



One of four 274 ft. high towers aboard the *George F. Ferris* showing method of installing hydraulic jacks built by Yuba Manufacturing Division, Yuba Consolidated Industries, Benicia, Calif. George Bauer, of Delong Corp., New York, is shown supervising construction while platform is being completed at Yuba's Richmond, Calif., plant.

YUBA gets quality-cost-delivery advantages by specifying 16 Sandusky cylinders

Sixteen 500-ton hydraulic jacks built by Yuba, for which Sandusky supplied the main cylindrical bodies, enable the new pipe-laying barge, *George F. Ferris*, to drill in waters 200 ft. deep!

This 5400-ton barge is equipped with four structural steel towers 274 ft. high. Four jacks on each of the towers provide the power to lower these steel "legs" to the ocean floor, raise the barge above the surface of the water, or retract the towers to render the barge navigable. The steel jack cylinders are Sandusky Centrifugal Castings, made to the requirements of ASME Code-approved SA-217, Section VIII, Unfired Pressure Vessels, to withstand operating pressures of 3000 psi. They were produced in 186" lengths, machined to 24" O.D. with 2" thick walls and sectioned into four pieces 43" long.

Yuba's selection of Sandusky Centrifugal Castings was based largely on three essential factors: QUALITY—meeting the exacting Code requirements . . . COST—saving about half the cost of an alternate method of manufacture . . and DELIVERY—coming through on a tough time schedule by delivering all 16 cylinders within 21 working days!

When you need cylinders from 7" to 54" in O.D. and up to 33 feet long it will pay you to get in touch with us. Write for our latest booklet, *Your Solution To Cylindrical Problems* containing data on more than 70 ferrous and non-ferrous alloys.

SANDUSKY CENTRIFUGAL CASTINGS
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SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

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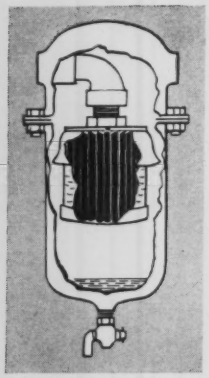
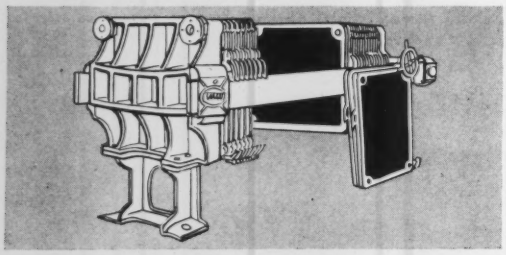
Why FELT BY FELTERS Makes An Ideal FILTERING MEDIUM



Felt has controlled permeability and particle retention efficiency which makes it ideal for filtration of air, gases and liquids. Wool felt is non-reactive to many chemical agents and can be made chemically neutral.

Felt can be fabricated into a wide variety of shapes for use in industrial air filtration, air conditioning, and for processing chemicals, paints, film dope and nutrient broths. Also ideal for use in particle retention for radioactivity monitoring.



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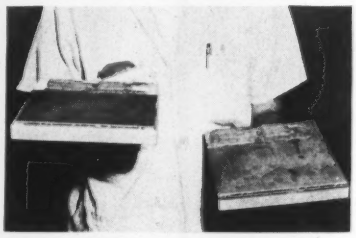
MATERIALS AT WORK

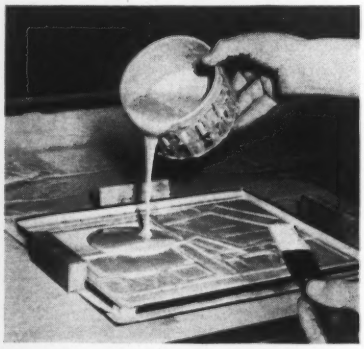


Epoxy-backed electrotype *(left) weighs 1 lb, 14 oz; identical lead electrotype (right) weighs over 5 lb.*

than shaving to correct printing height. In addition, they offer high strength, impact resistance and resiliency; low shrinkage; and resistance to most chemicals.

The new electrotype, called Electroplastic, consists of a copper printing shell (half the thickness of standard shells) to which is cast a backing of epoxy resin. Up to the point of producing the copper shell, production techniques are similar to those used for conventional electrotypes. And although sensitizing, silvering and plating of the vinyl mold are also similar, plating time to produce the shell is said to be half that previously required.

First step in producing the new electros is to build up a shallow dam on the top half of the shell to retain the poured resin. The mold is then placed on a vacuum table and epoxy resin is poured (see photo). The epoxy cures under thermostatically controlled infrared lamps in about 40 min. When the epoxy hardens, the vinyl mold is stripped from the plate. After shaving, the plate is ready for adhesive mounting to a



Resin is poured *on top of copper printing shell.*

News about COATINGS FOR METALS
from Metal & Thermit Corporation

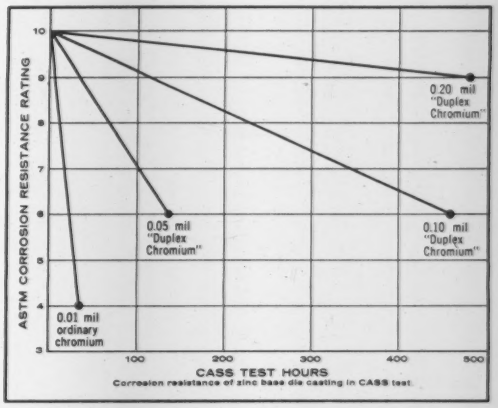
How to get the optimum protection of bright chromium plating

There are three requisites to increasing corrosion protection from chromium plating. (1) The deposit must be sufficiently thick. (2) There should be a crack-free chromium base topped by a special, finely cracked chromium deposit. (3) The plate should be more uniformly distributed over the part, so that recessed areas, too, are assured at least 0.03 mils minimum chromium thickness.

All of these requirements are easily met through UNICHROME SRHS® CHROMIUM plating processes. Work done for the automotive industry, long plagued by corrosion of brightwork in outdoors exposure, provides a good case in point.

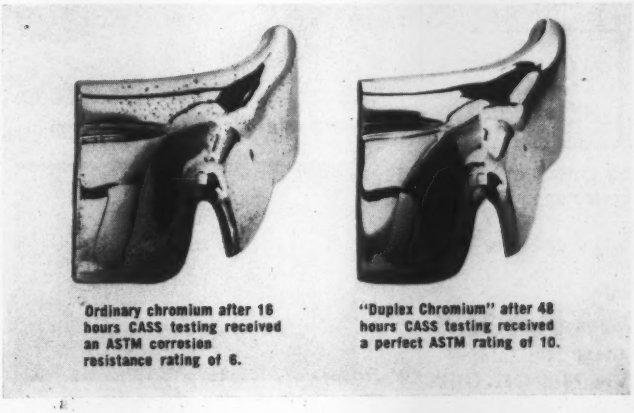
AN ANSWER TO OUTDOOR CORROSION

Note the results in the chart at right. In all cases, the thickness of undercoats was kept constant. Only the chromium plate was varied... from ordinary to "Duplex", and progressively thicker. M&T "Duplex Chromium" calls for first using Unichrome Crack-Free Chromium and its ability to throw into recesses and give a more uniform and fracture-free plate. This is followed by another deposit of Unichrome SRHS Chromium, with its *controlled* cracking. With increasing thickness, the protection increased tremendously. Durability as determined by rigorous, accelerated corrosion testing techniques was multiplied as much as *20 times*.



Zinc die cast specimens, all plated with 0.75 mil copper and 0.75 mil nickel prior to chromium lasted as shown above in the severe CASS test (Copper accelerated acetic acid salt spray). Ordinary chromium fared poorly. Optimum protection was approached by using Crack-Free Chromium and increasing the deposit thickness.

Steel bumper sections, showing difference in protection between ordinary chromium and Unichrome "Duplex Chromium."



Ordinary chromium after 16 hours CASS testing received an ASTM corrosion resistance rating of 6.

"Duplex Chromium" after 48 hours CASS testing received a perfect ASTM rating of 10.

WIDELY USEFUL FINISH

While the above case concerns itself specifically with an automotive problem, it indicates what thicker chromium in general, and crack-free chromium in particular can do for other design problems involving corrosion and wear. This plate blocks infiltration of corrosives to underlying metal.

Technical Papers giving full details on the advantages of thicker chromium deposits are available for the asking. Write METAL & THERMIT CORPORATION, Rahway, New Jersey.

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FOR HIGH SPEED FABRICATION

NEW INSUROK®

Free-Machining, Laminated, Rolled Tubes Meet Mil-P-79B and Federal L-L-3

INSUROK GRADE	NEMA GRADE	MILITARY SPECIFICATIONS	FEDERAL SPECIFICATIONS
T-300	X	Mil-P-79B, Type PBM, Form TR	L-L-31, Type 1, Grade X
T-301	XX	Mil-P-79B, Type PBG, Form TR	L-L-31, Type 1, Grade XX

T-300 and T-301—two new, improved grades of INSUROK paper base, laminated tubes are distinguished by their excellent FREE MACHINING characteristics. They do not chip or delaminate when fabricated. Having good dielectric properties and uniform appearance, these light colored INSUROK tubes are suited to any fabricating operation. You can machine INSUROK T-300 and T-301 at top operating speeds.

For your electrical and mechanical applications you are offered a wide choice of tube sizes in these new grades:

- Inside diameters up to 12 inches
- Wall thicknesses up to 2 inches

CHARACTERISTIC PROPERTY COMPARISON

CHARACTERISTIC PROPERTIES	NEMA XX REQUIREMENTS	T-301 TYPICAL VALUES
	Test Samples From 1" x 1¼" Tubes	
Water Absorption	2% maximum	1%
Density (grams per CM^3)	1.12 minimum	1.25
Dielectric Strength (perpendicular to laminations)	290 volts/mil. minimum	400 volts/mil.

Richardson offers a complete line of INSUROK laminated grades in sheets, rods and tubes . . . also provides complete fabrication service at its Melrose Park, Illinois and New Brunswick, New Jersey plants.

For full information on INSUROK T-300 and T-301, write direct or contact sales offices in principal cities.

the RICHARDSON COMPANY

LAMINATED AND MOLDED PLASTICS Founded 1858

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wood block or metal base.

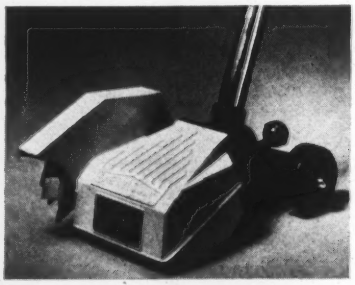
The plates can be used for both flat and curved printing and are competitive in price with standard lead-backed electros. According to Shell, curved plates have made runs of close to two million impressions with no sign of appreciable wear.

Seven Die Castings Key to Unit's Low Cost

The use of seven zinc die castings for main components of a new combination lawn edger and trimmer is said to be responsible for the unit's low cost and efficiency.

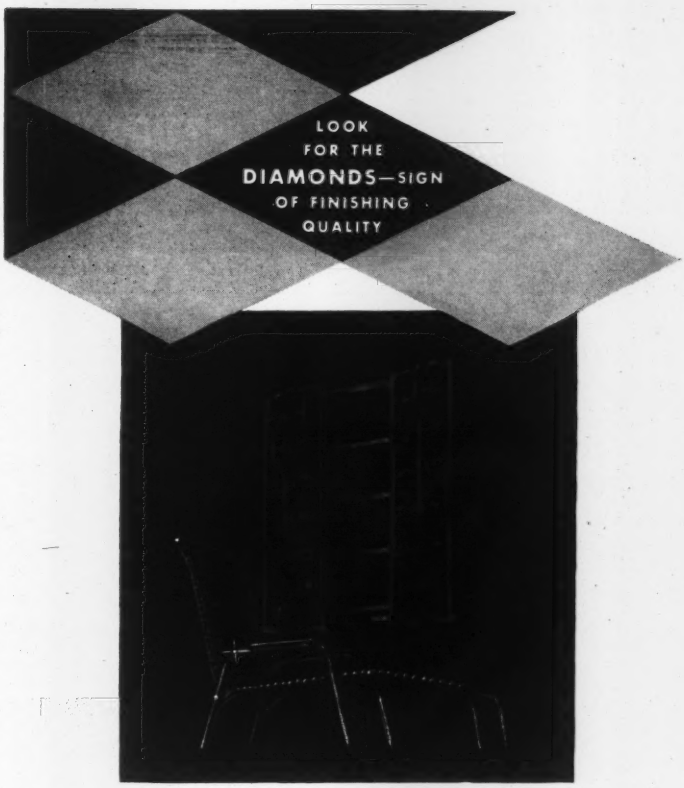
According to the American Die Casting Institute, any other method of fabrication would have necessitated either a greater number of parts or excessive machining costs. Except for simple broaching, the zinc die castings are virtually ready for assembly as received from the caster (see photo). The four parts which make up the housing and guards are easily and economically coated in bright yellow or red enamel with conventional painting equipment.

Another reason given for the selection of zinc die casting is its ability to maintain close dimensional tolerances.



Lawn edger and trimmer uses . . .

. . . seven zinc die castings.



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CLEAR PROTECTIVE COATINGS

Now, here's a fast, easy, economical way to almost double the protection against corrosion on your product. Simply follow up the IRIDITE process with a fast, easy application of IRILAC . . . and you've given your product extra protection for longer resistance to corrosive conditions, longer shelf or storage life protection from handling, and increased beauty for more attractive appearance and faster sales.

ON ALUMINUM

An IRIDITE-IRILAC finish will provide longer life for storm doors, windows, outdoor furniture, auto parts and accessories, tubing or wire goods. And, you have a choice of color finishes such as natural aluminum and golden yellow. Other colors may be obtained by an additional dye operation.

ON MAGNESIUM

IRILAC over an IRIDITE No. 15 finish increases corrosion protection, and provides resistance to finger printing and abrasion on all types of products, with color appearance ranging from light to dark brown.

ON ZINC

IRIDITE plus IRILAC gives your product longer life and brighter appearance. Color choices range from clear IRIDITE to olive drab, plus colored dye finishes.

IRIDITE is the tradename for a specialized line of chromate conversion coatings that can be applied to any non-ferrous metal by brush, dip or spray methods—at room temperatures—manually or with automatic equipment. Upon application, a thin film forms which becomes an integral part of the metal itself, and thus cannot chip, flake or peel. No special equipment, exhaust systems or specially trained personnel are required.

IRILAC is the tradename for a line of clear protective coatings for all metals. As safe and easy to handle as water, they may be applied by brush, dip or spray methods. No exhaust or special fire protection equipment required. Adds protection and abrasion resistance to any base metal, plated part or parts treated with electrolytic or chemical post treatments, without chemical change.

For complete technical information on IRIDITE Chromate Conversion Coatings or IRILAC Clear Protective Coatings, write for FREE TECHNICAL MANUAL. Or, see the Allied Field Engineer in your area. He's listed under "Plating Supplies" in the yellow pages.

Allied Research Products, Inc.

4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co.

Chemical and Electrochemical Processes, Anodes, Rectifiers Equipment, and Supplies for Metal Finishing

IRIDITE® Chromate Coatings	IRILAC™ Clear Coatings	ISOBRITE® Plating Brighteners	ARP® Chemicals & Supplies	WAGNER Line of Equipment

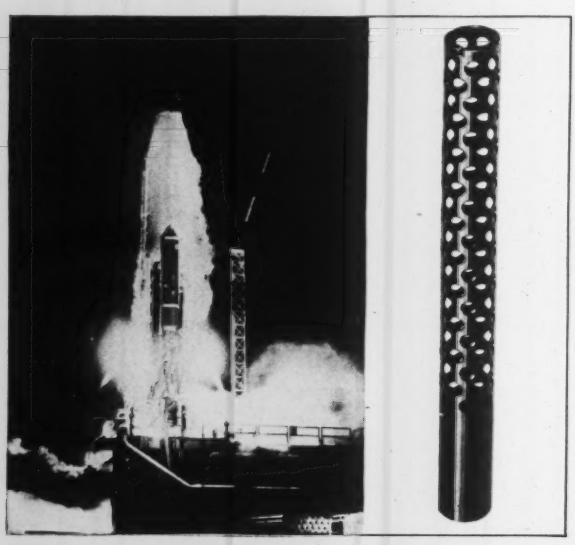
For more information, turn to Reader Service card, circle No. 490

BISHOP Tubular Products NEWS

"METALS FOR PRECISION AND PERFORMANCE"

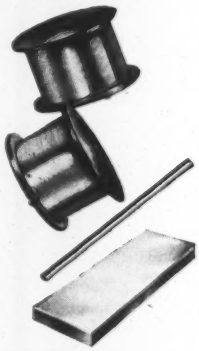
BISHOP QUICK SERVICE TEAM SOLVES STICKLER IN ATLAS PROGRAM

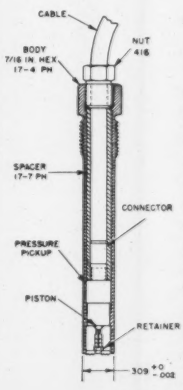
Telemetering bulb part (illustrated)—originally of 304 seamless tubing—cracked during fabrication. BISHOP specialists were called in—304L seamless, ½ hard was recommended and supplied (against a tough deadline). *Results:* The 304L part met all requirements, including critical resistance to vibration fatigue within a temperature range of –80° to –380°F in inert helium, and gave completely satisfactory performance in the Atlas program. More information on 304L—or any BISHOP tubular products? Use the coupon.



BIMETALLICS NOW AVAILABLE IN MANY DIFFERENT FORMS, METALS

Bimetallics—the new family of composite metal products—is solving problem after problem these days. BISHOP capabilities in producing bimetallics are almost endless. Both *base* and *precious* metals are available in wire, sheet, and tubing form. *Typical example of popular bimetallic for glass sealing applications:* nickel-iron alloys over copper wire in sizes from .004 to .125 in. diameter . . . advantages: *low* electrical resistivity, *good* thermal conductivity. Look into the possibilities of improving *your* products . . . use the coupon.





17-7 PH* TUBING BEING DRAWN TO HYPODERMIC SIZE

Small diameter 17-7 PH tubing, welded and seamless, is available from BISHOP now on standard order in sizes down to .375 in. OD X .035 in. wall—on special order to .020 in. OD X .006 in. wall. Accompanying illustration shows a piezoelectric transducer used for measuring pressures up to 100,000 psi in ballistics and hypersonic research work. Use of welded 17-7 PH spacer in transducer permitted finish machining of the part *before* heat treating. Want more data on BISHOP's 17-7 PH products or other super alloys? Use the coupon.

**Trademark of Armco Steel Corporation*

J. BISHOP & CO.

platinum works

FOR HELPFUL DATA USE THIS HANDY COUPON

- ☐ **Bimetallics,** Data Sheet PA–1
- ☐ **17-7 PH alloy,** Data Sheet TA–2A
- ☐ **304L alloy,** Data Sheet TA–2
- ☐ **Tubular Products,** Bulletin No. 12
- ☐ **Platinum Metals Products,** Catalog No. 3

Check information you'd like and mail to J. BISHOP & CO., 40 King St., Malvern, Penna.

Name _____

Position _____

Company _____

Address _____

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Tubular Products Division

40 KING STREET, MALVERN, PENNA.

NIagara 4-3100

THIS IS THE BISHOP LINE:

Products of all the Platinum Metals... Small diameter Stainless Steel, nickel and special alloy tubing

For more information, turn to Reader Service card, circle No. 365

New Trade Society

The Ductile Iron Society is the name of a new nationwide trade association concerned with "metallurgical research, product development and promotion, technical advice, and operational improvement."

The organization, with headquarters located in Cleveland, has elected as president Robert S. Thompson, H. P. Deuscher Co. For further information contact James H. Lansing, executive secretary, Ductile Iron Society, P. O. Box 858, Cleveland 22.

New Labs Study Materials

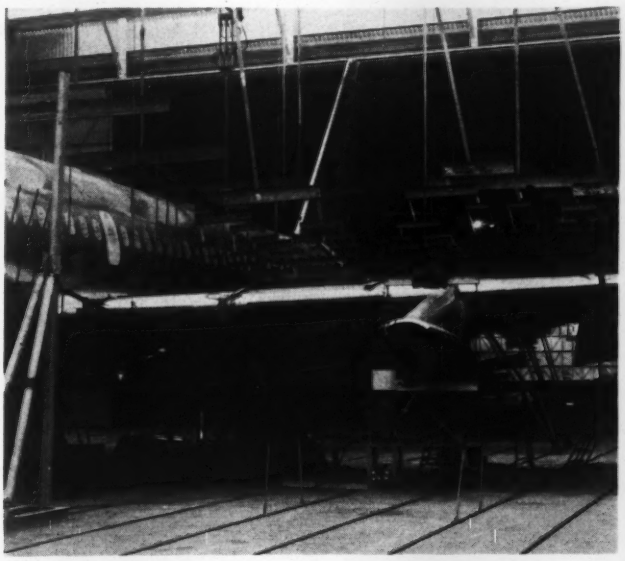
The following brief reports cover three new laboratories where research will be conducted on engineering materials and processes.

▸ A new $2-million research laboratory devoted to high temperature structures has been built by Convair, a division of General Dynamics Corp.

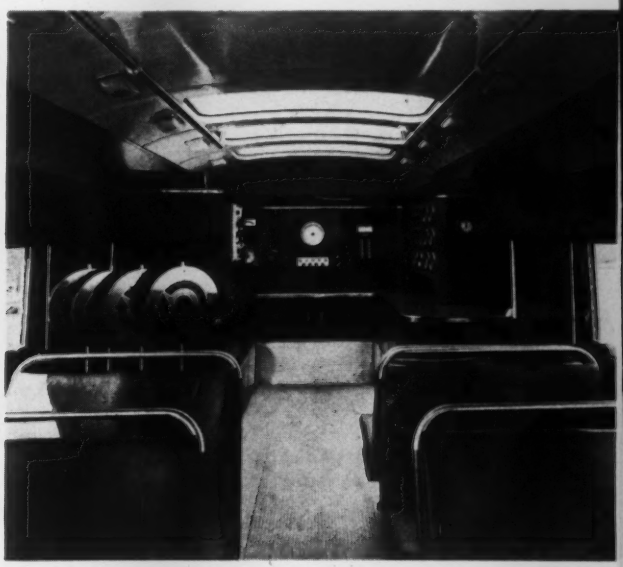
The lab, equipped to simulate aerodynamic loads up to 500 tons and temperatures ranging from —300 to 15,000 F, will be used to research and develop materials for high speed aircraft, missiles and space vehicles. Some of the problems to be studied include skin buckling, thermal fatigue, and other results of thermal strains created by high speed maneuvers, re-entry conditions, and acceleration and deceleration.

▸ The development of synthetic lattices specifically tailored to hundreds of different industrial applications will be the exclusive aim of a new million dollar laboratory constructed by the Chemical Div., International Latex Corp.

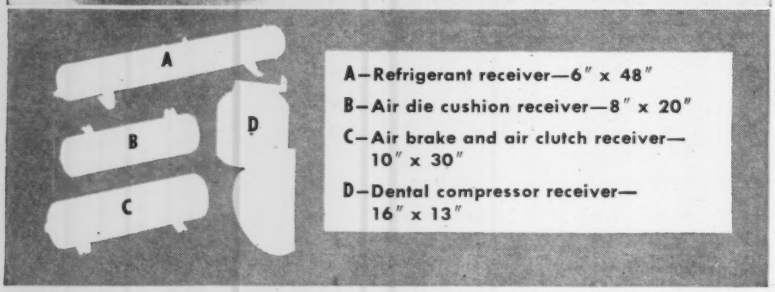
The lab will concentrate on problems of liquid latex applications in paints, nonwoven fabrics, paper, foam rubber, dipped goods, textiles and adhesives. The laboratory's approach will be to first determine whether an existing material meets customer specifications. If not, the appropriate team of researchers will



***Aerodynamic stresses** are simulated with static testing equipment in Convair's high temperature structures laboratory.*



***Mobile laboratory** will study all aspects of motor vehicle performance.*



A—Refrigerant receiver—6″ x 48″
B—Air die cushion receiver—8″ x 20″
C—Air brake and air clutch receiver—10″ x 30″
D—Dental compressor receiver—16″ x 13″

Hackney air receivers...made to your specifications for any service

Whatever your special requirements or standard applications, your Hackney air receivers will meet all code requirements. And they'll be made two-piece, with *one* weld uniting the deep drawn sections into a strong, lightweight receiver.

Standard Hackney air receivers, horizontal model, are available in capacities of 30, 60, 80 and 120 gallons; vertical models, in 60- and 80-gallon sizes. Specially designed receivers for refrigerants or compressed air vary in capacity with their specifications.

For complete information on Hackney air receivers, write today.

Pressed Steel Tank Company
Manufacturer of Hackney Products
1442 South 66th Street, Milwaukee 14, Wisconsin
Branch offices in principal cities
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Hackney MILWAUKEE — Quick-Union Iron Works

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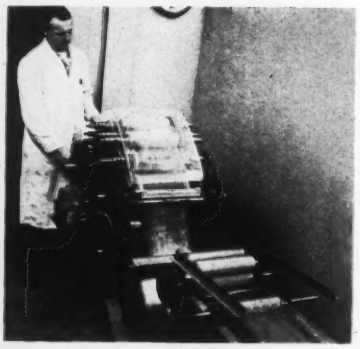
News OF INDUSTRY



***Nonwoven fabrics** are among many materials developed in International Latex Corp.'s new laboratory.*

attempt to develop a modified material or an entirely new formulation which will do so.

In addition to solving customer problems, the lab will attempt to develop such things as: a latex-impregnated gasket paper with superior oil and water resistance; a latex paint for nonferrous metals; an adhesive for foamed-in-place resins; and an anti-crocking agent for textiles which has improved resistance to heat and light discoloration.

▸ The world's first mobile laboratory specially designed for on-the-road studies of every aspect of motor vehicle performance was recently given to the University of Michigan by International Nickel Co. Some of the materials research projects planned are: corrosion problems in automotive structures, and stress and vibration during road operation. The mobile laboratory will also test, by way of performance, a new sintered plate nickel-cadmium battery.

Underwriters Ease Plastics Restrictions

The furor which recently resulted when Underwriters Laboratories restricted the use of plastics in room air conditioners, refrigerators, radios and television sets to "self-extinguishing or better types" has now abated.

A third "meeting of clarification" was held Apr 30 and actually clarified at least three questions: 1) the

MT. VERNON DIE CASTINGS help STANLEY develop stronger, lighter, tougher heavy-duty builders' saws

CASE HISTORIES FROM MT. VERNON FILES

Stanley packs more power into its new line of low-cost, heavy-duty saws . . . and saves important weight doing it! They have been designed for greater utility, with such features as: Ball bearing guard — fingertip depth-or-bevel setting, uncluttered front — window brush-holder for simpler servicing, extra handling comfort, positive control, etc. Yet, with all these improvements, Stanley is still able to sell these better saws for less!

A big reason for this lower cost is Mt. Vernon's coordinated four-fold die casting service: designing, die-making, casting and machining. Mt. Vernon worked closely with Stanley* to create light, thin-walled aluminum castings with strength to spare. All parts are produced with excellent surface finish to facilitate barrel burnishing. Many fit together without machining thereby contributing to lower manufacturing and assembly costs.

Stanley is typical of the leading manufacturers in the power tool industry who know and rely on Mt. Vernon's experience and facilities for die cast zinc and aluminum parts. As the largest independent die casting company — with over 200,000 square feet under one roof — our services and equipment are ready to help solve your design and production problems. We'll be glad to discuss the advantages of die castings with you at any time. Just call your nearest Mt. Vernon sales representative.

*Stanley Electric Tools, New Britain, Conn.

MT. VERNON DIE CASTING CORP.

STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

SALES REPRESENTATIVES

BROOKLYN, N. Y.: Mr. Robert V. Moore, 2317 Plumb 2nd St.
CLEVELAND, OHIO: Mr. Grant Eller, 6 East 194th St.
GUILDERLAND, N. Y.: Mr. David H. King, 75 Willow St.
LUTHERVILLE, MD.: Mr. C. McIntosh Gordon, Box 55, R.R. No. 1
PITTSBURGH, PA.: Mr. Andrew W. Anderson, 300 Pasadena Drive So.
QUINCY, MASS.: Mr. Edmund W. Libby, 91 Merrymount Rd.
ROCHESTER, N. Y.: Mr. William Sauers, 101 Briarcliff Rd.
SKANEATELES, N. Y.: Mr. Jerome J. Theobald, 9 E. Genesee St.
STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

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We don't know what your product is, so we can't talk specifics. But we do know this . . . hundreds of manufacturers have successfully switched to Farlite High Pressure Plastic Laminates to improve product quality . . . or lower production costs . . . or make a new product application possible! A Farlite engineer stands ready to help you! Meanwhile . . .

WRITE FOR YOUR FREE COPY OF NEW CATALOG AND PRODUCT SUGGESTION CHART

FARLITE HIGH PRESSURE PLASTIC LAMINATES ARE A QUALITY PRODUCT OF THE
PLASTICS DIVISION • FARLEY & LOETSCHER MFG. CO., DUBUQUE, IOWA

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ruling was not intended to categorically eliminate the use of slow burning plastics in the equipment described, but was intended to restrict those materials which represented a hazard; 2) slow burning plastics knobs are acceptable in air-conditioning equipment if no other combustible materials are used in the interior of the equipment; and 3) slow burning plastics grills or decorative fronts are acceptable in air conditioning equipment if no other combustible materials are used in the interior and if the grills are far enough away from the electrical system to prevent their igniting in the event of electrical failures.

A fourth statement, which is not quite so clear, is: "These slow burning materials may be used under other conditions depending on the design of the equipment."

Special Short Courses

The following special courses on engineering materials and processes were described in detail in the April, May and June issues:

Massachusetts Institute of Technology—Materials for Parachute and Retardation Devices (July 20-31).

Boston College—Industrial Spectrography (July 20-31).

University of Michigan—Modern Approach to Machining Problems (Aug 24-28).

New York University—Titanium Metallurgy (Sept 14-15).

Ohio State University—Nondestructive Testing (Sept 14-25).

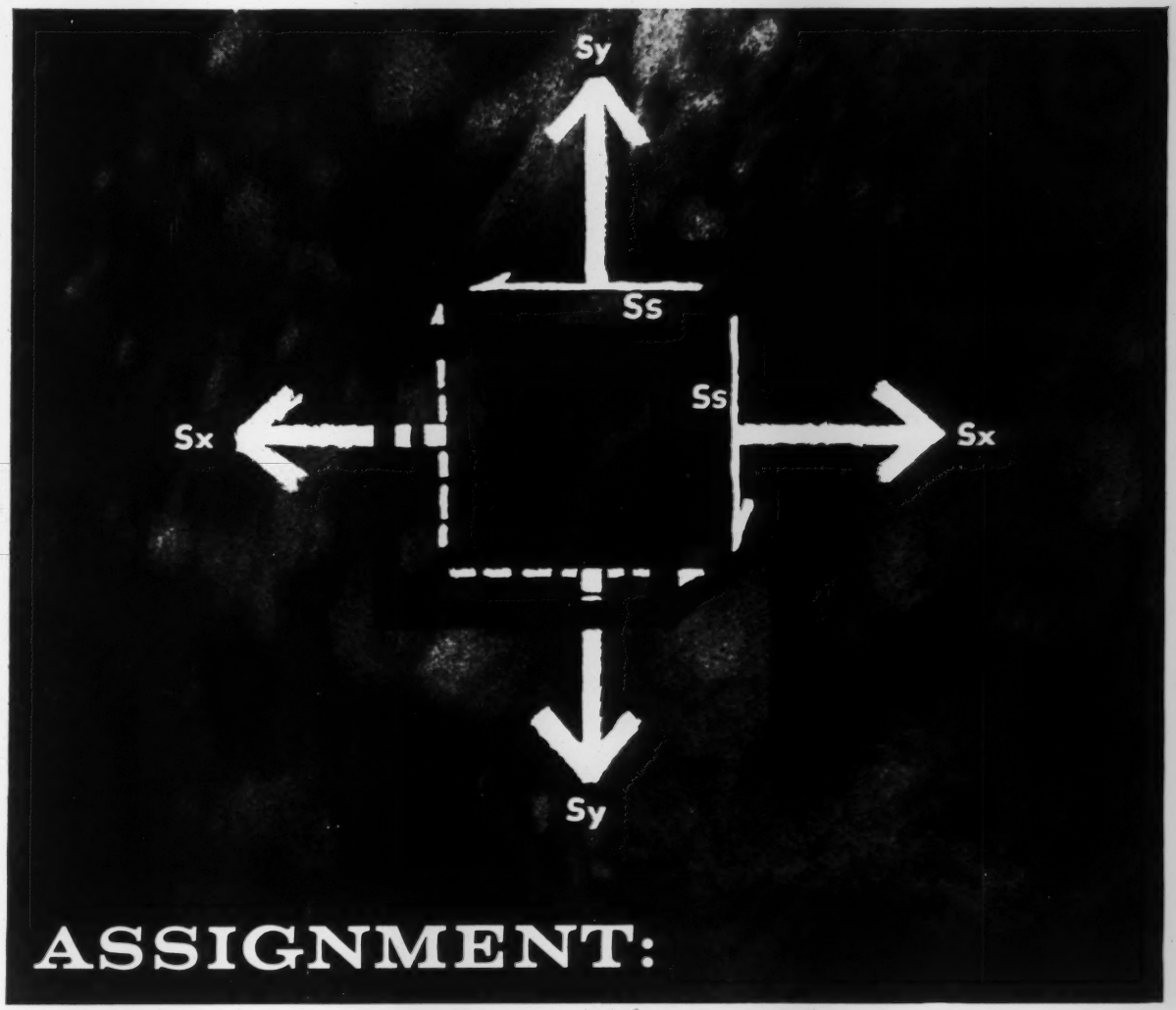
Engineers

Dr. Augustus B. Kinzel, Union Carbide Corp., has received the Stevens Institute of Technology Powder Metallurgy Medal Award.

John P. Magos has been appointed director of engineering, Crane Co.

Russell C. Weigel, E. I. du Pont de Nemours & Co., Inc., has been elected president and director of the Society of the Plastics Industry, Inc.

Alexander B. Magnus, Jr., has been named to the newly-created position



ASSIGNMENT:

ABRASIVE IMPACT

How Lukens *Application Research* helps you find the right steel plate for the job

If your assignment is designing equipment to withstand abrasive impact, our Application Engineering staff can serve you. Their specialty is helping you track down the precise steel plate for any job. They research a problem from the design stage right through to how the equipment has performed for years after its installation. This practical observation and experience—combined with metallurgical know-how—is yours for the asking. It's been saving our customers money for years.

For example: working recently with a conveyor engineer, our people showed why 321 min. BHN quality Lukens "T-1" would perform equally as well as a previously used metal costing twice as much. On the other hand, the same group has suggested the regular quality of Lukens "T-1" for a uranium mine skip hoist, where a slightly softer steel will actually hold up longer. In still another conveyor application—in a coal preparation plant—our engineers demonstrated how stainless steel, Type 304, would produce long-term savings. The high initial cost of stainless was reduced by using it in Lukens clad plate form.

If your assignment is abrasive impact, why not let it be our assignment, too? Contact Manager, Application Engineering, D79 Services Building, Lukens Steel Company, Coatesville, Pa. Also....

Helping Industry Choose Steels That Fit The Job

LUKENS

ASK FOR LUKENS "T-1" STEEL BULLETIN

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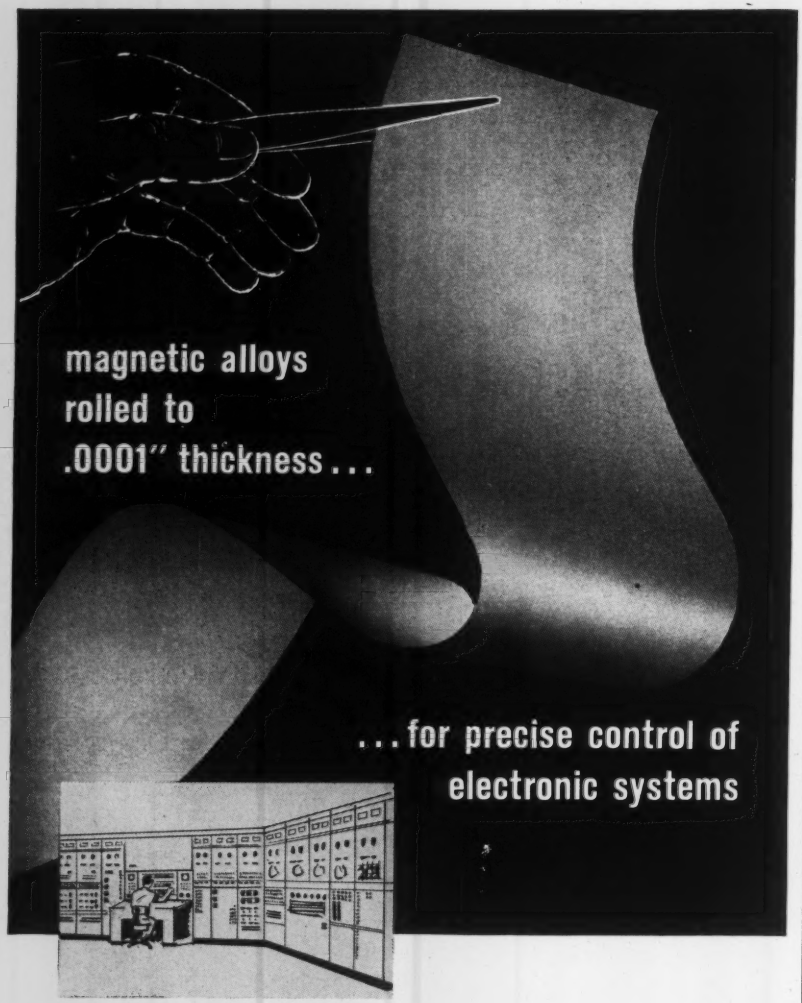
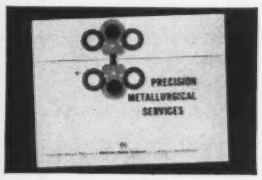


Now you can obtain high magnetic permeability alloys such as 4-79 Moly Permalloy, Alfenol, and HyMu "80" in cold rolled strip and foil in **production** quantities! The unique and newly expanded facilities of Precision Metals Division are geared to produce ultra-thin metal strip and foil in any quantity and in virtually any alloy.

Precision Metals strip and foil for development and production offer these special advantages:

uniform magnetic properties
thicknesses from .010" to .0001"
dimensional uniformity
extremely close tolerances
excellent surface characteristics

For specific requirements, Precision Metals can also furnish custom alloys to your own specification in the form you need. Write today for fully illustrated facilities booklet, DE-7.



HAMILTON
WATCH COMPANY / **Precision Metals Division**
Lancaster, Pennsylvania

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News OF INDUSTRY

of staff analytical engineer and design specialist, Actuation Research Corp., Glendale, Calif.

Royal A. Stone has been appointed head of Rolock Inc.'s new Process Equipment Div.

William W. Davis has been appointed prestress planning engineer, Leschen Wire Rope Div., H. K. Porter Co., Inc.

Raymond R. Chapman has been named manager of the plastics plant, Parts Div., Sylvania Electric Products Inc.

Dr. Adrien LeDuc has been appointed research associate, M. W. Kellogg Co., a subsidiary of Pullman Inc.

Dr. Robert C. Springborn has been named manager of research, Marbon Chemical Div., Borg-Warner Corp.

Dr. Richard H. Valentine is now director of research and development, New Departure Div., General Motors Corp.

James D. Moore has been named plant manager at Vitro Uranium Co.'s mill in Salt Lake City.

Robert O. Nellums, Lowell L. Fellinger, and **Donald L. Eby** have been appointed assistant directors, Engineering Dept., Organic Chemicals Div., Monsanto Chemical Co.

John A. Buzby has been named project engineer, General Devices, Inc.

S. Paul Shackleton is now staff scientist, Research and Development Div., W. L. Maxson Corp.

Adolph A. Karrasch has been named director of manufacturing, Hercules Motors Corp.

Harold I. Gregg has been named design engineer, J. E. Lonergan Co.

James R. Brown, Jr., has been named director of manufacturing, Dresser Industries, Inc.

Dr. Italo S. Servi has been made director of research, Metals Div., Kelsey-Hayes Co.

Dr. Harry P. Kling has been appointed manager, Nuclear Components Dept., Nuclear Div., Martin Co.

George Hindmarsh has been named parts manager, Sherman Products, Inc.

Dr. Morton Z. Fainman is now director of research, Bray Oil Co.

Victor Carbone has been appointed manager, West Coast plant, Components Div., Fairchild Controls Corp.,

PRODUCT-DESIGN BRIEFS FROM DUREZ

- **A plastic for potentially hazardous locations**
- **Material for a non-warping switch**
- **More design freedom in metal castings**

Canopy retards fire

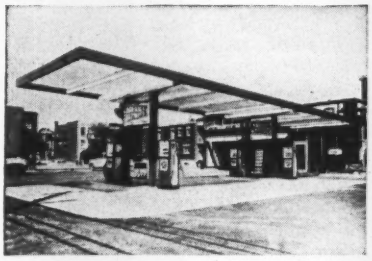
Good product ideas seem to work almost anywhere.

Take, for example, this plastic gas-station canopy. So far as we can tell, the idea of cool, light-diffusing canopies over the gas pumps started in the South, where it would seem to be a natural.

However, the canopy you see here is in Canada. It does most of its work in winter, when it may have to hold up the weight of five feet of snow and ice.

The marketing strategy is sound. A motorist doesn't mind so much getting out of his car in bad weather when he's protected overhead; and the attendant, too, is likelier to provide that extra bit of service.

There's something else that's different about this canopy. It doesn't support combustion, because it's made with Hetron® self-extinguishing polyester resin. A fire starting at a pump won't spread along the canopy to other pumps or to the station building.



If it weren't for self-snuffing Hetron, there'd be few places where a good idea like this could operate. Fire retardance is chemically locked into the resin, not added later at the expense of strength. The resulting combination of structural properties gives you something unique on which to base *your* new-product ideas.

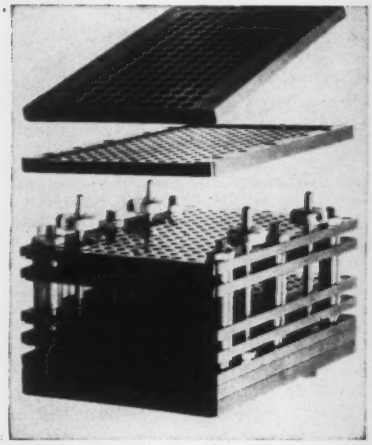
If you'd like to know more about Hetron resins, let us send you the complete technical data file, together with names of leading fabricators in this country and Canada who can make U/L-listed panels and custom-molded shapes for you.

Less dough for this "bread"

Needed: a dimensionally stable material for the "bread" in this sandwich-like multiple switch assembly (above right).

Why dimensionally stable? Because each of the seven "slices" in the sandwich has 187 holes that must line up with matching holes in the other plates.

What low-cost insulating material would hold alignment without risk of moisture absorption and warping? Could



holes be *molded*, rather than drilled, to the required accuracy? Would this save money?

The material recommended by the custom molder was a fast-curing Durez compound with good moldability and excellent dimensional stability. This material does everything the designers want it to do. Its exceptionally good mold release facilitates the low-cost molding of holes. In addition, numbers and letters which were formerly silk-screened on the plates are now molded-in for extra savings.

Result: a smooth-functioning, non-warping switch, produced with the utmost economy. It's just one more proof of the wide, wide spectrum of design requirements you can meet at low cost with Durez phenolics (and often *only* with phenolics). Want more information on these versatile molding compounds? Just check the coupon for a bulletin on Durez materials.

Castings – can do

Don't back off from a complex metal shape just because "it can't be done."

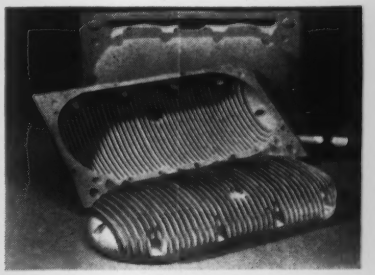
Instead, talk to your foundryman. He may have a surprise up his sleeve—*shell molding*. It saved the day for the aluminum-alloy gearbox cover, below.

Designers wanted as many heat-dissipating fins as possible; they compromised on 40. Even so, fins tore when the piece was poured in sand. Three men could produce only 20 good castings a day.

A switch to shell molding has made the casting economically feasible. Three men now turn out 70 per day. Dimensions are much more consistent from one casting to the next. As a bonus, engineers found they could squeeze two more fins into the design to get higher efficiency than they first believed possible.

What about cost? Shell-molded castings sometimes cost more *per pound* than regular castings. But they often save you far more than the difference—by reducing machining and finishing time and by speeding assembly.

Like to know how these better castings are made with the help of Durez foundry resins? We'll gladly send you the new 36-page "Durez Guide to Shell Molding" if you check the coupon below.



For more information on the Durez materials mentioned above, check here:

- ☐ Hetron fire-retardant polyester resins (50A)
- ☐ General bulletin on Durez materials (Bulletin 400)
- ☐ "Durez Guide to Shell Molding" (36-page bulletin)

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

DUREZ PLASTICS DIVISION

1407 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

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CHR

COHRlastic R-10470

Silicone Sponge Rubber

Flexible at extreme temperatures
−100°F to 500°F

COHRlastic R-10470 has a dense, uniform, non-absorbing closed cell structure. It has superior compression set, excellent dielectric properties, immunity to aging, ozone and weather, good chemical resistance and is odorless, non-corrosive, non-sticking.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Ideal for gasketing, vibration damping, fairing strips, seals, pads, bumpers, cushions and other applications where resiliency at high or low temperatures is required.

Available from distributor stock: sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″. Larger sizes and special molded and extruded shapes made to order.

COHRlastic R-10470

TYPICAL PROPERTIES

Tensile	50-130 psi
Elongation	175-225%
Water absorption *(Immersion 24 hrs. @ 75°F.)*	3-6%
Density, lbs./cu. in.	.020-.030 (firm) .013-.018 (medium)
Low temperature brittleness *(5 hrs. @ −100°F., bend flat)*	No cracking
Compression deflection *(compressed to 75% of original thickness)*	
Room temperature	
Type firm	12-18 psi range[1]
Type medium	8-14 psi range[1]
−65°F. pct. difference	−10% to +15%[1]
212°F. pct. difference	+ 5% to +10%[1]
Compression set *(compressed to 50% of original thickness)*	
22 hrs. @ 70°F.	0-5% (firm)[1] 5-30% (medium)[1]
22 hrs. @ −65°F.	0-5% (firm)[1] 5-30% (medium)[1]
22 hrs. @ 212°F.	10-25% (firm)[1] 20-50% (medium)[1]

[1] ASTM D1056-56T

FREE SAMPLES and folder

Leader in Fabrication of Silicone Rubber Products

CHR CONNECTICUT HARD RUBBER CO.
Main Office: New Haven 9, Connecticut

For more information, circle No. 447

News OF INDUSTRY

a subsidiary of Fairchild Camera and Instrument Corp.

Dr. Alden H. Ryan has been named manager, Microwave Laboratory, General Electric Co., Palo Alto, Calif.

Aimison Jonnard has been named assistant manager, polymer planning and applications, U. S. Industrial Chemicals Co.

George Ustin has been appointed vice president in charge of engineering, Buchanan Electrical Products Corp.

Alton F. Davis died May 25 at the age of 69. He was vice president and secretary of Lincoln Electric Co.

Companies

Scovill Mfg. Co. has begun operations in its new $10-million tube mills in New Milford, Conn.

Melpar, Inc., a subsidiary of Westinghouse Air Brake Co., has consolidated all of its Boston and Watertown plant activities into a single Applied Science Division.

E. I. du Pont de Nemours & Co., Inc., will construct a new $20-million plant in Florence, S. C., for the manufacture of Mylar polyester film.

Picker X-Ray Corp.'s New York City office has been moved to 75 Varick St.

Claremont Pigment Dispersion Corp. has broken ground for a 10,000-sq ft addition to its Roslyn Heights, N. Y., plant.

Hydromatics, Inc., has established a new design, engineering and manufacturing division at 7120 Remmet Ave., Canoga Park, Calif.

Computer Systems, Inc., is the new name for **Mid-Century Instrumatic Corp.,** New York City.

Air Reduction Sales Co., a division of Air Reduction Co., Inc., has built a new oxygen and nitrogen plant in Denver, Colo.

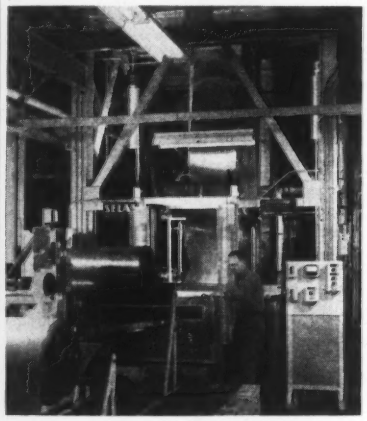
Flintkote Co. has acquired **Blue Diamond Corp.** of Los Angeles.

Dayton Industrial Products Co. is a newly formed division of Dayton Rubber Co. The new division will have headquarters in Melrose Park, Ill.

Kaiser Aluminum & Chemical Corp. and **Mexico Refractories Co.,** Mexico, Mo., have reached a merger agreement whereby Mexico Refractories

THE FINISH IS ONLY THE BEGINNING

To meet demands for perfect finish on stainless and nickel Thinstrip®, Somers installs unique new annealing furnace.



This new Selas vertical continuous annealing furnace assures uncontaminated, commercially unmarred surfaces as well as uniform temper and faster delivery on stainless, nickel and nickel alloy Thinstrip up to 25″ wide. But this is only part of the story of Somers' quality. Sendzimir rolling mills, Accu-Ray gauging plus 50 years leadership in thin gauge metals (from .010 down to .000125″) are a few of the features Somers offers to assist you with your Thinstrip® problems.

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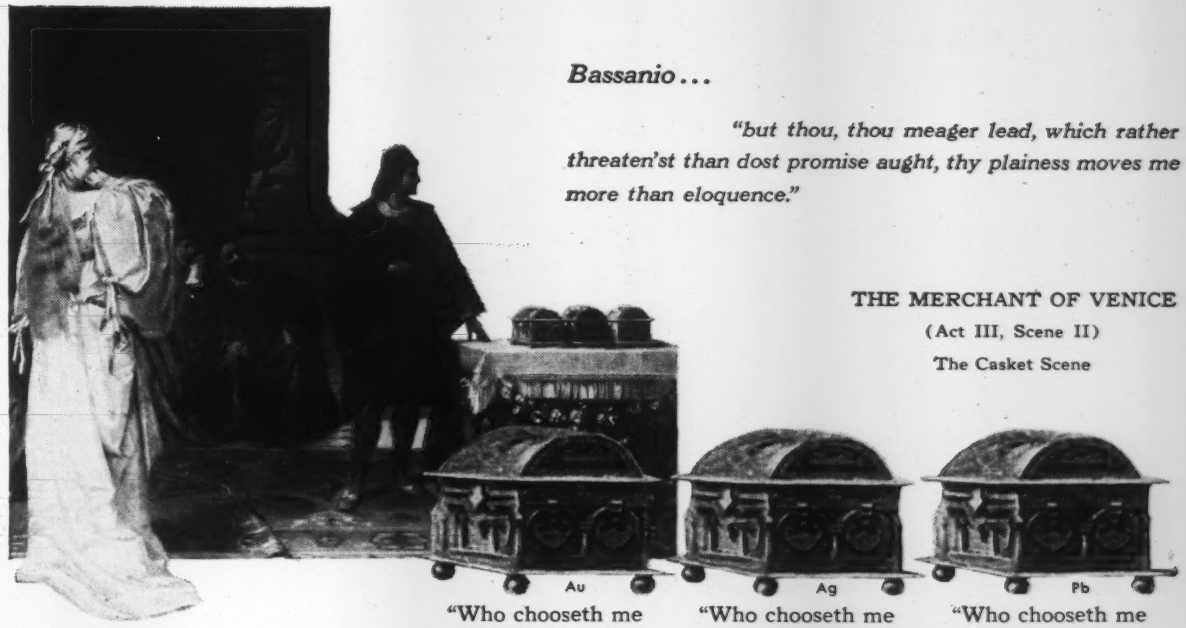

Bassanio . . .

"but thou, thou meager lead, which rather threaten'st than dost promise aught, thy plainess moves me more than eloquence."

THE MERCHANT OF VENICE
(Act III, Scene II)
The Casket Scene

"Who chooseth me shall gain what many men desire."

"Who chooseth me shall get as much as he deserves."

"Who chooseth me must give and hazard all he hath."

You may recall Portia and the three chests . . . one of gold; one of silver, and a third of lead. In one of them lay her portrait, and to that one of her three suitors who guessed wherein it lay, she, herself, was pledged. Bassanio shrewdly guessed that the plain leaden sheath hid the coveted token.

LEAD, *The Precious Metal*

Like Bassanio, in the Merchant of Venice, the scientist and engineer of today have seen beyond the commonplace appearance of lead and found in its unique properties, practical applications which not even the noble metals can provide.

From the time-tested uses of lead in its pure or alloyed state to the newer applications of the organo-chemical compounds, the metal is providing the solution to many of the metallurgical problems arising in this rapidly expanding economy of the nuclear age.

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Maximum sizes up to 1¾", ½ oz.

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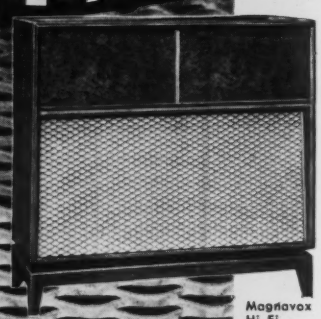

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For more information, turn to Reader Service card, circle No. 417

News OF INDUSTRY

will operate as a division of Kaiser in conjunction with Kaiser's Chemical Div.

Polymer Industries, Inc., a subsidiary of Philip Morris, Inc., has begun construction of additional manufacturing, laboratory and office facilities at its Springdale, Conn. plant.

Consolidated Electrodynamics Corp.'s Systems Div. has been incorporated as a wholly-owned subsidiary of the parent company and will be known as **Consolidated Systems Corp.**

Gulf Oil Corp. has opened a new facility for electronic data processing equipment at its Harmarville, Pa. laboratories.

Holan Corp., a wholly-owned subsidiary of Ohio Brass Co., has purchased **Universal Hydraulics, Inc.,** which will be operated as a subsidiary of Holan.

Texas-U. S. Chemical Co. plans to move its headquarters from New York City to Port Neches, Tex.

Hydrometals, Inc. has purchased **Midwest Metals, Inc.,** a wholly-owned subsidiary of Fluor Corp., Ltd.

Harvey Aluminum has moved to 426 Olive St., San Diego, Calif.

ACDC Electronics, Inc., is the new corporate name for **NYT Electronics, Inc.,** Burbank, Calif.

Bell Telephone Laboratories, American Telephone and Telegraph Co., will build a $20-million laboratory at Holmdel, N. J.

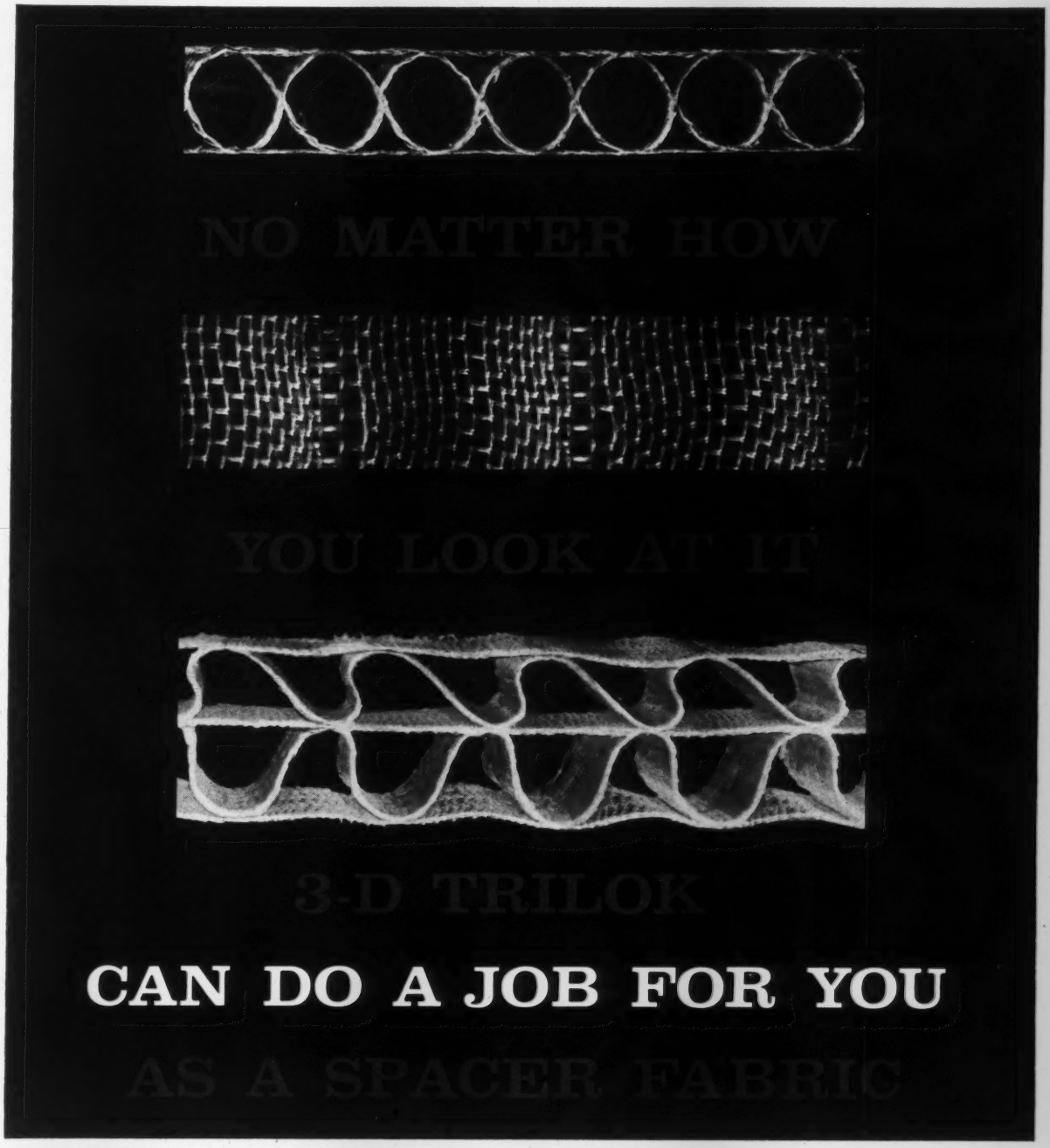
Thomas A. Edison Industries has moved to 169 Main St., West Orange, N. J.

General Electric Co.'s Insulating Materials Dept. has established an insulation application center.

Brush Beryllium Co. will soon complete a 15,000-sq ft addition to its alloy rolling facilities in Elmore, Ohio.

R. C. Mahon Co. has acquired **Walter G. Mitchell Industries, Mitchell Steel Inc.,** and **Mitchell Properties Inc.,** and will merge the three affiliated California firms with those of Mahon

USE THE 'SELECTOR'—You will find properties of most engineering materials, plus names and addresses of suppliers, in M/DE's *Materials Selector* reference issue, published last October.



TRILOK is a versatile, stabilized weave of polyethylene and Saran® which comes in eight standard thicknesses from .100 to 1.00 inches. It is resilient, porous, corrosion and chemical resistant, shock absorbent, flexible and light. *Consider it for: vibration dampeners, filter units, seating supports, ventilated cushions, protective packaging.* For full details, write:

Textile Division

United States Rubber

Rockefeller Center, New York 20, N.Y.

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No. 3 of a series

Eastman 910 Adhesive solves another production bottleneck

Recordak Corporation, New York City, offers microfilming equipment that photographs and endorses bank checks in one operation.

Rubber endorsing plates, rather than steel, were preferred yet could not be used because of the difficulty of securing the flexible rubber plate to the steel back, permanently and quickly.

The problem was solved with Eastman 910 Adhesive.

Coated lightly with adhesive, the plates are held in alignment in a simple jig. In a matter of minutes, the bond is formed... and the unit is ready for delivery and installation. *Field tests show the bond lasts for the life of the rubber printing plate.*

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

Bonds Almost Instantly ...Without Heat, Pressure or Catalyst

For a trial quantity (⅓-ounce) send five dollars to Armstrong Cork Company, Industrial Adhesives Division, 9107 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Division, Dept. E-7, Kingsport, Tenn.

For more information, circle No. 407

News of Industry

in a new plant to be constructed in Torrance, Calif.

Brush Beryllium Co. will establish a new beryllium fabrication plant in the San Francisco, Calif., area.

Electric Storage Battery Co. has purchased the assets and business of American Machine & Foundry Co.'s Battery Laboratory at Raleigh, N. C.

Societies

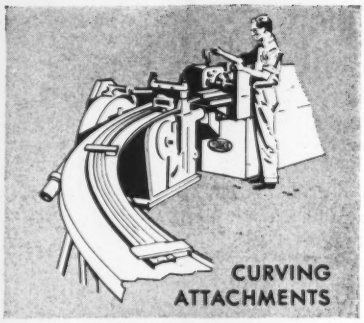
Metal Powder Industries Federation has elected the following officers: president—George A. Roberts, Vanadium-Alloys Steel Co.; executive secretary and treasurer—Kempton H. Roll; *Metal Powder Producers Assn.:* president—Charles E. Hanson, National-U. S. Radiator Corp.; *Metal Powder Core Assn.:* president—Benjamin J. Falk, Arnold Engineering Co.; *Ferrite Mfrs. Assn.:* president—William W. Garstang, Allen-Bradley Co.; and *Powder Metallurgy Equipment Assn.:* president—Byron B. Belden, Baldwin-Lima-Hamilton Corp.

American Zinc Institute announces the following officers: president—R. G. Kenly, New Jersey Zinc Co.; vice presidents—T. A. Campbell, Anaconda Sales Co., H. D. Carus, Matthiessen & Hegeler Zinc Co., and E. H. Snyder, Combined Metals Reduction Co.; treasurer—G. H. LeFevre, U. S. Smelting, Refining and Mining Co.; and executive vice president and secretary—J. L. Kimberly.

Institute of Environmental Sciences is the name of the new organization resulting from the merger of the Institute of Environmental Engineers and the Society of Environmental Engineers. Officers are: president—Harold C. Jones, Air Arm Div., Westinghouse Electric Corp.; executive vice president—William Vandal, Autonetics Div., NAA; and executive secretary—Henry F. Sander, Vapor Heating Corp.

National Screw Machine Products Assn. has elected the following officers: president—Leonard R. Schaeffer, Mechanical Art Works, Inc.; vice president—Charles L. Kerr, Kerr-Lakeside Industries; treasurer—Roland G. Herker, Herker Screw Products, Inc.; counsel and executive vice president—Orrin B. Werntz; and secretary—Margaret S. Ballinger.

Zirconium Assn. is a newly-formed group of companies that produce,



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for profitable mass production

High speed, YODER Cold Roll-Forming machines are the most economical method for mass producing structural or ornamental shapes. One machine with one operator can form up to 40,000 feet of shapes per day. Even on a part-time basis, a YODER Cold Roll-Forming machine can prove to be a profitable investment.

YODER flexibility works for you too, curving, coiling, ring forming, multiple roll-forming and embossing—on a wide variety of metals—can be incorporated into your production line. Practical, YODER-engineered design minimizes maintenance and downtime... assures uniformity, accuracy and reliability of your end product.

In addition to Roll-Forming machinery, YODER also makes a full line of Rotary Slitting equipment, Pipe and Tube mills. Send for the fully descriptive Cold Roll-Forming Book.

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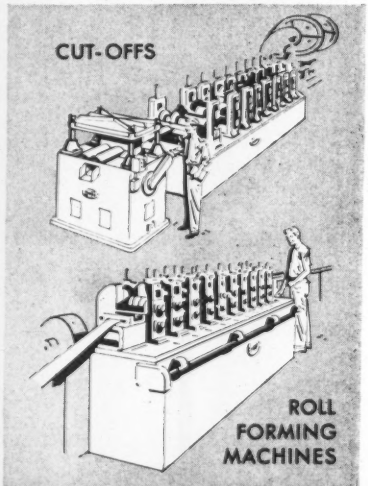

ENGINEERING YODER MANUFACTURING **COLD ROLL FORMING MACHINES**

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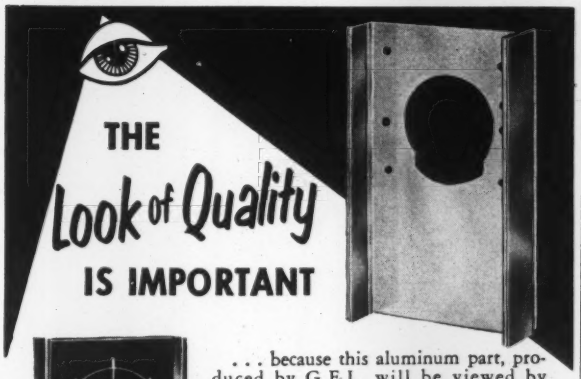

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Gaskets	Vapor barriers
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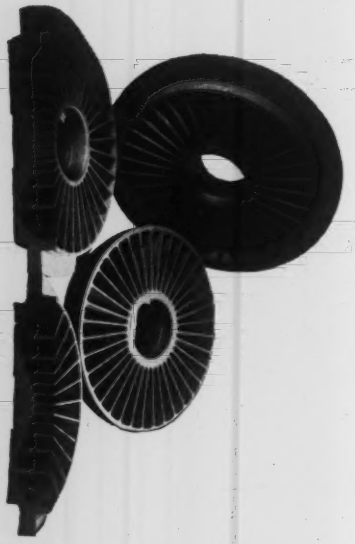

Ductile iron fluid couplings to withstand high shock diesel service are cast in quantity. Their smoothness and accuracy save considerable machining time as a result of the unusual foundry methods of Morris Bean & Company, Yellow Springs 21, Ohio.

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News OF INDUSTRY

melt and process zirconium. Headquarters are at 2130 Keith Bldg., Cleveland 15. W. B. Thomas. Thomas Asso., Inc., is executive director.

Meetings

DENVER RESEARCH INSTITUTE, METALLURGY DIV., 8th annual conference on applications of x-ray analysis. Estes Park, Colo. Aug 12-14.

INSTITUTE OF RADIO ENGINEERS AND WESTERN ELECTRONICS MFRS. ASSN., 1959 Western electronic show and convention. San Francisco. Aug 18-21.

METALLURGICAL SOCIETY, American Institute of Mining, Metallurgical, and Petroleum Engineers, conference on properties of elemental and compound semiconductors. Boston. Aug 31-Sept 2.

SOCIETY OF THE PLASTICS INDUSTRY, INC., Midwest Section conference. French Lick, Ind. Sept 10-11.

AMERICAN CHEMICAL SOCIETY, 136th national meeting. Atlantic City, N. J. Sept 13-18.

STEEL FOUNDERS' SOCIETY OF AMERICA, 57th fall meeting. Hot Springs, Va. Sept 21-22.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept 24-26.

AMERICAN WELDING SOCIETY, fall meeting. Detroit. Sept 28-Oct 1.

SOCIETY OF THE PLASTICS INDUSTRY, INC., 15th New England Section conference. Portsmouth, N. H. Oct 1-2.

AMERICAN SOCIETY FOR TESTING MATERIALS, 3rd Pacific Area national meeting. San Francisco. Oct 11-16.

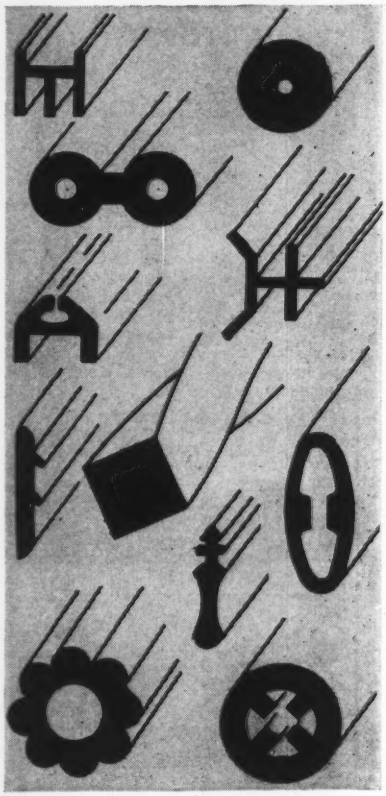
15TH NATIONAL ELECTRONICS CONFERENCE, American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and University of Illinois. Chicago. Oct 12-14.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall general meeting. Chicago. Oct 11-16.

FEDERATION OF PAINT AND VARNISH PRODUCTION CLUBS, 37th annual meeting and 24th paint industries' show. Atlantic City, N. J. Oct. 20-24.

NON-FERROUS FOUNDERS' SOCIETY, annual meeting. Bedford Springs, Pa. Oct 23-24.

ACE PLASTIC EXTRUSIONS



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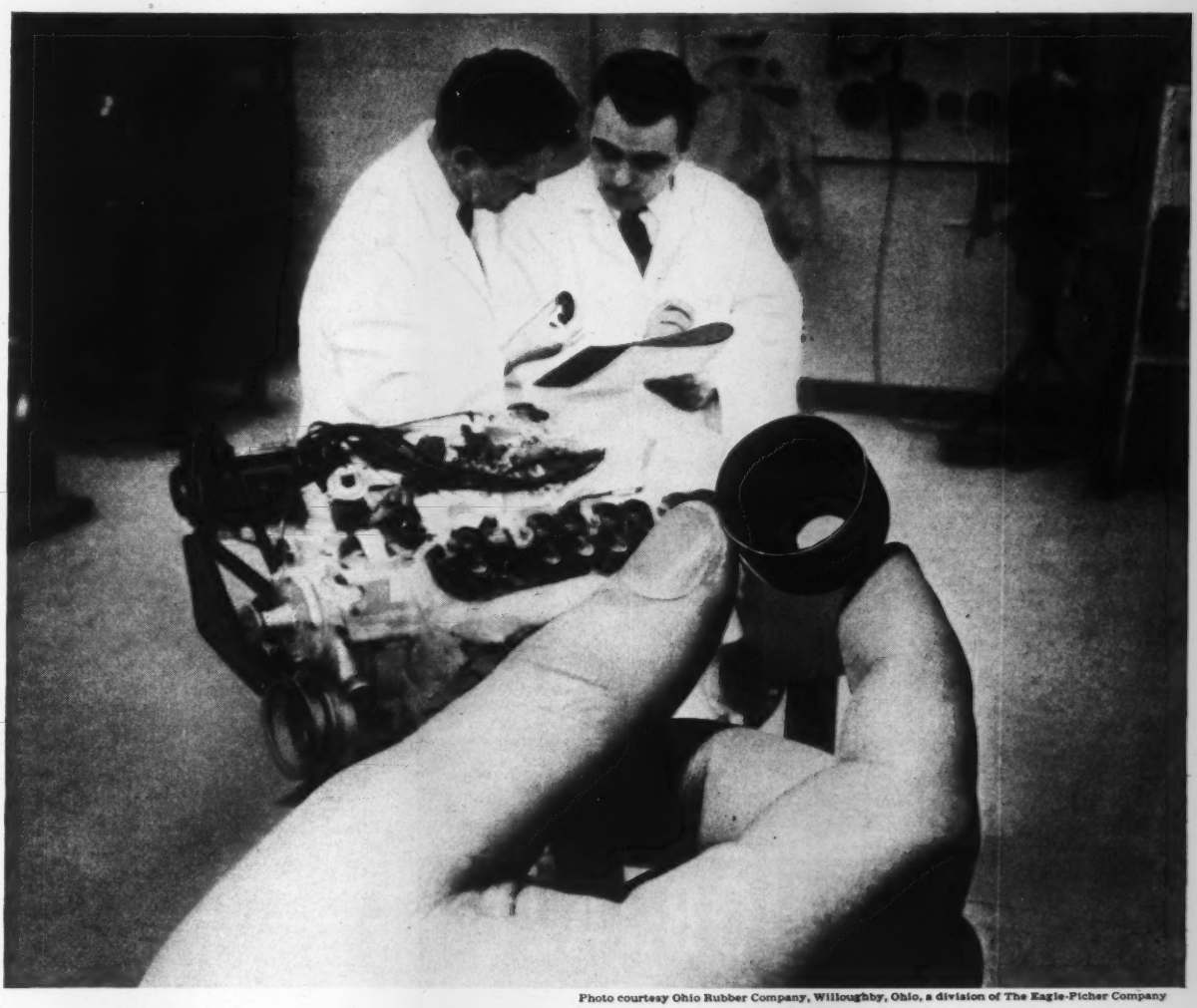

Photo courtesy Ohio Rubber Company, Willoughby, Ohio, a division of The Eagle-Picher Company

How's this for a surefire success?

This thimble-size shield works inside an automobile engine. It clings to a pulsing valve stem, prevents excessive loss of engine oil–yet allows enough oil to properly lubricate the stem. Obviously, a tough job for a tiny part.

To do this critical job, rubber seemed the likely choice. But it would have to be a very special kind of rubber. It would have to withstand constant contact with oil, intense vibration and compression, wide temperature extremes and great tension.

Material selected: CHEMIGUM, the nitrile rubber that maintains its dimensional stability under blistering-hot oil attack and the most demanding conditions. Hundreds of thousands of these valve stem shields are now in use – meeting every operational requirement. And the constant uniformity plus the easy processability of CHEMIGUM make their production practical and profitable.

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Air and Oil Channels Die Cast. No Costly Machining Necessary

DIE CASTINGS KEEP COSTS WAY DOWN

Producing the air drill handle (above) for the Cleco Air Tools Division of the Reed Roller Bit Company could have meant complicated, costly and extensive machining procedures. *But* Production Die Casting was called in and the handles were produced to exact specifications, saving time and machining costs for Cleco.

Die casting maintains the closest tolerances and allows maximum design flexibility. Quality is extremely high. High tensile strength zinc alloy (45,000 psi) and 360 Aluminum (40 to 43,000 psi) insure dense, durable castings. Call or write Production Die Casting Company, the South's leading die caster, to learn how you can keep production costs down without sacrificing quality.

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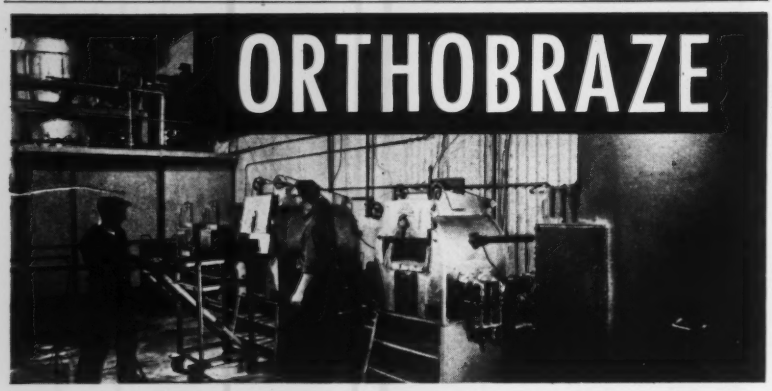

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TECHNICAL LITERATURE *(cont'd from p 48)*

Books

Silicones. *Robert N. Meals and Frederick M. Lewis. Reinhold Publishing Corp., New York. 1959. Plastics Applications Series. Cloth, 5 by 7 in., 267 pp. Price $5.95*

This is a book about all kinds of silicones including rubber-like materials, gums, compounds, pastes, resins, emulsions, fluids, lubricants and water repellents. The book is primarily concerned with uses, and only enough technical background has been included to make it reasonably self-contained. The various chapters cover properties, basic chemistry, manufacture, fabrication and future prospects for silicones. An appendix contains information on organosilicon compounds. The bibliography is short, intended only to guide the reader to publications and patents dealing with silicones.

ASTM Standards, 1958. *American Society for Testing Materials, Philadelphia. 1958. Cloth, 6 by 9 in.*

Part 1—Ferrous Metals (Specifications). *1622 pp. Price $12*

Standards for corrosion and heat resisting steels, wrought, cast and malleable iron, bar steels, titanium, magnetic materials, structural steels, ferroalloys and spring steels. Also covered: metal powder products; metallic coated steel products; and steel bars, castings, forgings, sheets, springs, plates, pipe, welding electrodes and rods.

Part 7—Petroleum Products, Lubricants, Tank Measurements, Engine Tests. *1420 pp. Price $12*

Standards for engine lubricating oils and greases, and electrical insulating oils. Also covered: motor and aviation fuels, petroleum solvents and naphthas, industrial oils and turbine oils.

Part 10—Textiles, Soap, Water, Atmospheric Analysis, Wax Polishes. *1532 pp. Price $12*

Standards for cotton, rayon, wool, felt and glass fabrics.

Filler Metals for Joining. *Orville T. Barnett. Reinhold Publishing Corp., New York. 1959. Cloth, 6 by 9 in., 253 pp. Price $7*

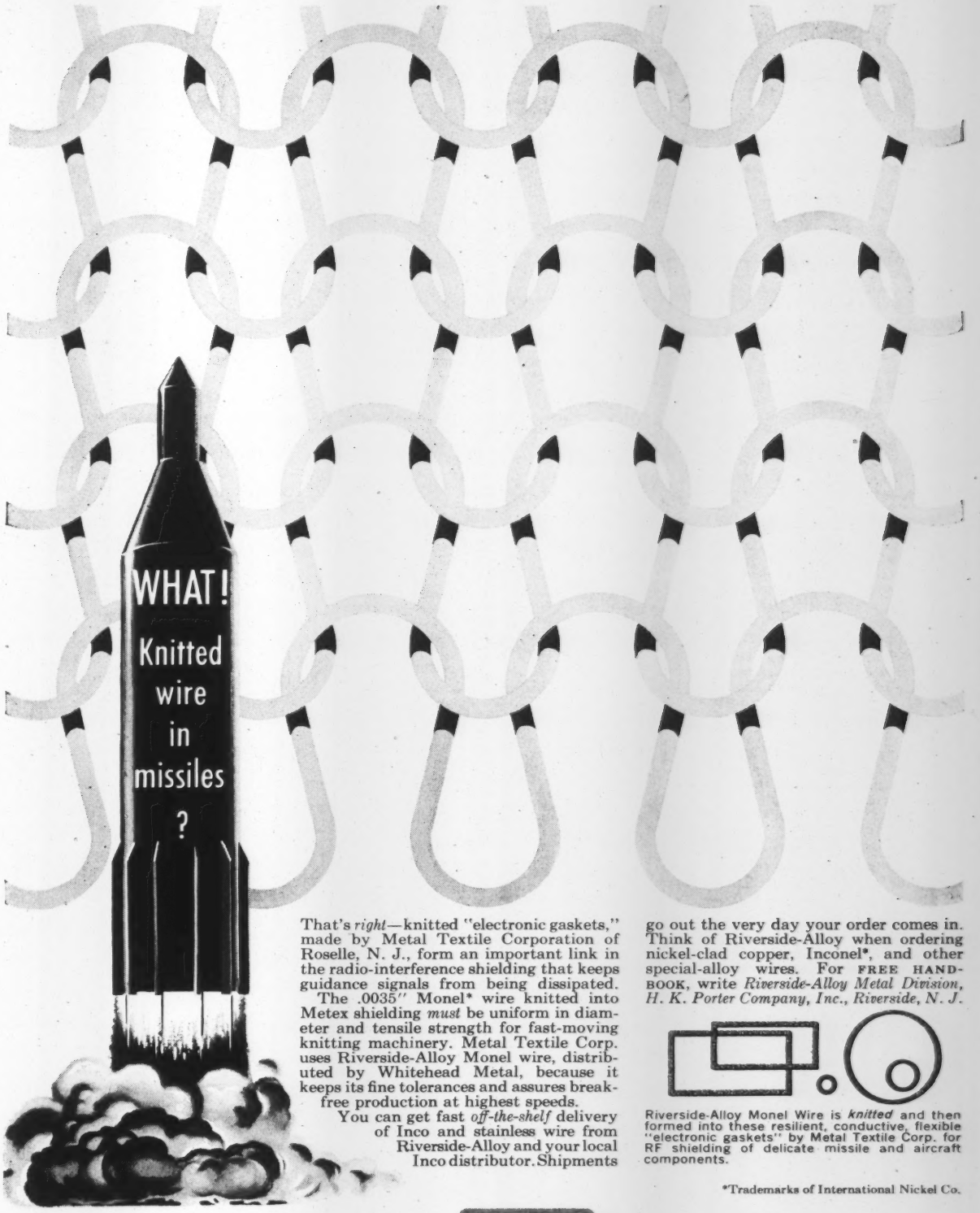
Properties, uses and specifications for mild and stainless steel, cast iron, aluminum, copper, nickel and tungsten filler metals for welding, brazing, soldering and surfacing. Information on arc welding electrodes and automatic welding of mild and low alloy steels.

Refractories Bibliography: 1947-1956. *University of Oklahoma Press, Norman, Okla. 1959. Cloth, 8 by 11 in., 943 pp. Price $7.50*

Contains over 9500 references to the periodical literature, and U. S. and foreign patents on refractories. Developments in high temperature materials during the 10-year period have been followed closely.

Lubrication Science and Technology: Vol. 1, No. 2. *Edited by John Boyd. Pergamon Press, New York. 1958. Cloth, 8½ by 11 in., 119 pp. Price $10*

Subjects discussed include: 1) lubrication of high speed, high temperature thrust ball



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bearings; 2) fretting of hardened steel in oil; 3) wear and frictional characteristics of some nickel-base alloys; 4) wear of cobalt-base alloys and stainless steel in high purity water; 5) synthetic sapphire as a bearing material; 6) effect of lubricant viscosity and type on ball bearing fatigue life; and 7) investigation of wear by electron diffraction.

Applied Mathematics for Engineers and Scientists. *C. G. Lambe. Macmillan Co., New York. 1959. Cloth, 6 by 9 in., 530 pp. Price $8.50*

Discusses dynamics, statics, hydromechanics and wave motion. Information on the motion of a particle, the plane motion of a rigid body, vector analysis, statics of a rigid body, statics of strings and chains, structural statics, stability of floating bodies, Bernoulli's equation for liquids and gases, stream functions, Legendre and Bessel functions, the wave equation and the heat flow equation.

Reports

Coating specifications REFERENCE INDEX OF THE CURRENT PROTECTIVE COATINGS SPECIFICATIONS. *Ordnance Tank-Automotive Command, Detroit Arsenal, U. S. Army. 159 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 151166)*

Federal, military and contractor specifications for numerous protective coatings used on aircraft, ammunition and tubing.

Spectral Emittance of Inconel SPECTRAL EMITTANCE OF UNCOATED AND CERAMIC-COATED INCONEL AND TYPE 321 STAINLESS STEEL. *J. C. Richmond and J. E. Stewart, National Bureau of Standards. Apr '59. 30 pp. Available from National Aeronautics and Space Administration, Washington, D. C. (No. 4-9-59W)*

Measurement of the normal spectral emittance of Inconel and type 321 stainless steel with different surface treatments at 900, 1200, 1500 and 1800 F over a wavelength of 1.5 to 15 μ. Surface treatments included electropolishing, sandblasting, and electropolishing followed by oxidation.

Refractory seals A STUDY OF REFRACTORY MATERIALS FOR SEAL AND BEARING APPLICATIONS IN AIRCRAFT ACCESSORY UNITS AND ROCKET MOTORS. *L. B. Sibley and others, Battelle Memorial Institute. Oct '58. 59 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.50 (PB 151483)*

Study of friction, wear and corrosion behavior of ceramic and cermet bearing and seal materials in an oxidizing atmosphere from 1000 to 1800 F. Several materials combinations including an alumina-chromium-molybdenum cermet, silicon carbide, alumina and a titanium carbide-nickel-molybdenum cermet showed promise for short-life rubbing seal applications, although rapid wear and erratic frictional behavior were observed.

Ductility of sheet metal A SIMPLE BEND TEST TO MEASURE UNIFORMITY OF DUCTILITY IN SHEET METAL. *S. V. Arnold, Watertown Arsenal. 6 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 151947)*

Describes a modified bend test that is easy to operate and conserves test material. The test correlates bend angles with the first visible evidence of rupture.

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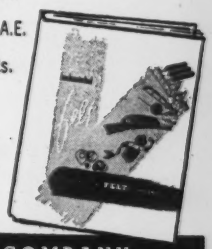

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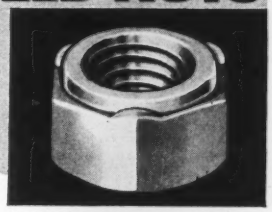

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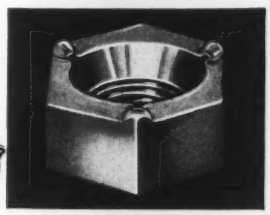

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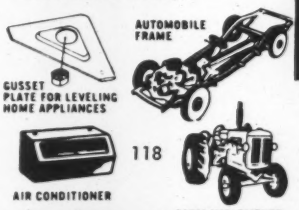

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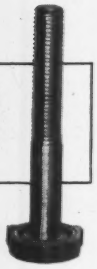

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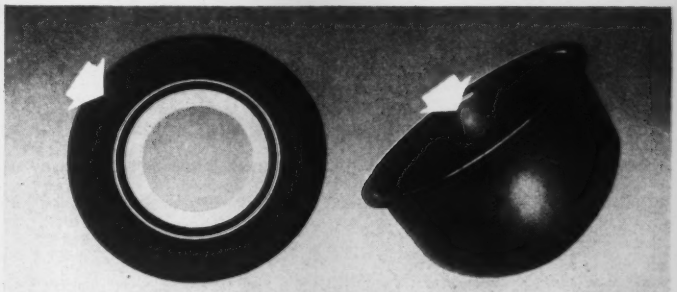

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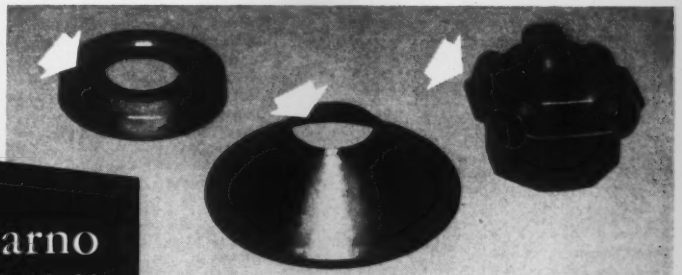

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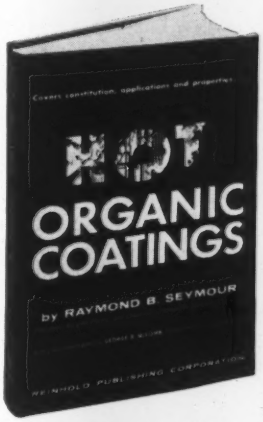

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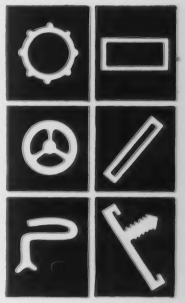

We extrude any shape in a variety of formulations to meet a wide range of design and performance requirements. Our complete tool and die shop is staffed with skilled technicians. We maintain a library of more than 400 section dies, one of which may fit your product design.

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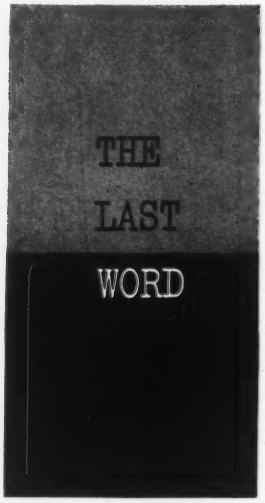


A Materials Society for You

by ***H. R. Clauser***
Editor

One of the fastest growing technical societies today is the Society of Aircraft Materials and Process Engineers. It is growing rapidly because it is filling an important need. It is providing the means for bringing together technical people whose job is the evaluation and selection of engineering materials and processes.

At present there are five autonomous regional chapters—two on the West Coast, one in the Southwest, one in the Midwest, and one on the East Coast. Perhaps the most important of their activities are regular meetings where subjects of common interest are discussed. For example, at the recent spring meeting of the Eastern chapter, papers on magnesium castings, reinforced plastics, high temperature dielectrics and adhesive bonding were presented.

As the name implies, the scope of SAMPE is limited at present to the aircraft and missiles field. However, if materials and process personnel in other industries should show sufficient interest in the organization, the scope of the society could be broadened. Enlarging the scope would seem to be a logical forward step and one that would result in greater interchange of experience and information among materials people in many different industries.

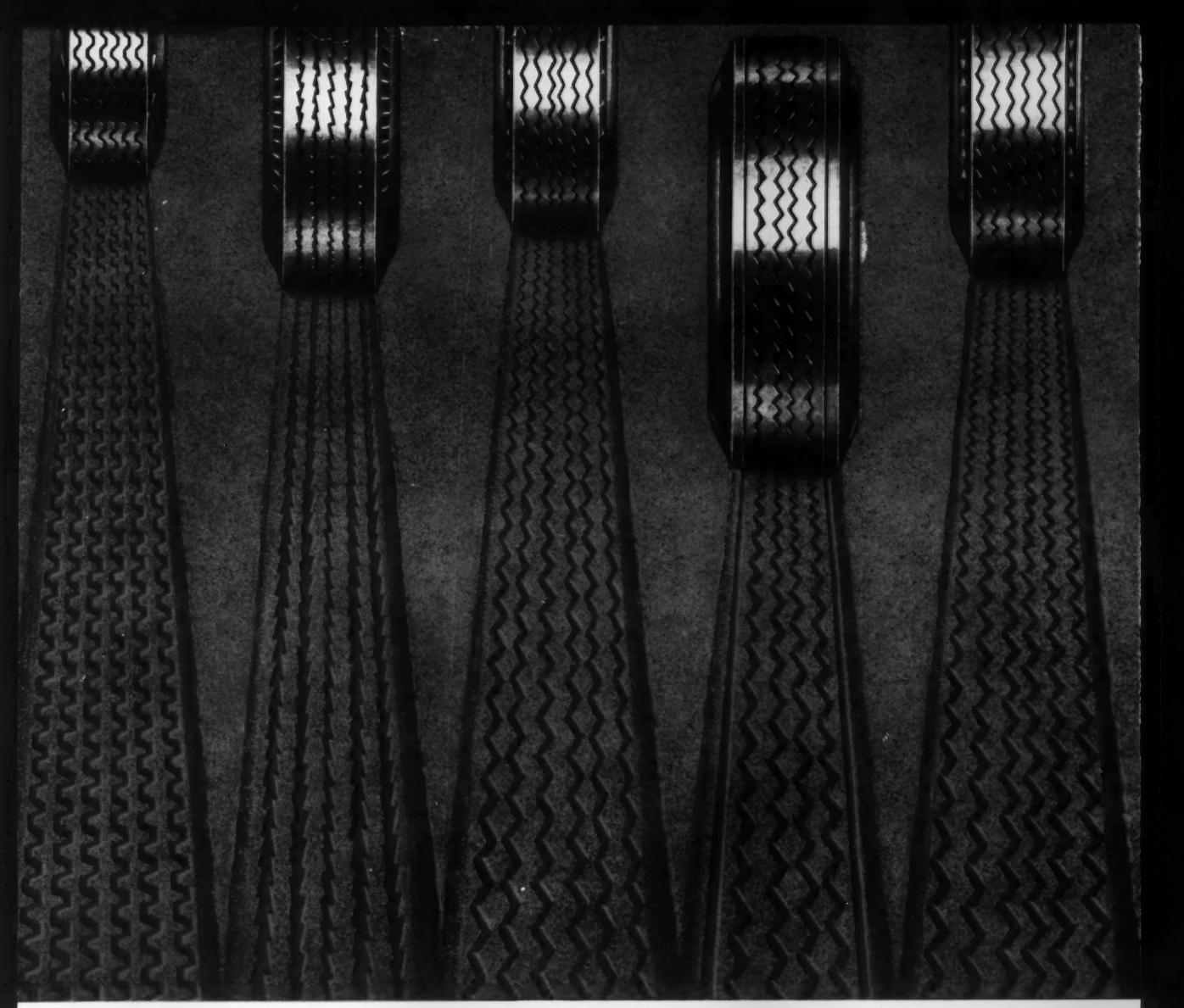
Because its aims closely parallel those of this magazine, we are happy to endorse and support SAMPE. And we urge all those engaged in the selection, use and processing of materials to become active in the society. If you are interested in learning more about the Society of Aircraft Materials and Process Engineers, drop us a card or letter and we will be glad to pass it along to the SAMPE chapter in your general area.

There Is Nothing Like a Dame

It is probably true that there is nothing like an attractive girl to draw men into a booth at a trade show. But the effectiveness of such lures is questionable. Over the years I have been enticed into many a booth by a model's dazzling smile, only to wander out again without even remembering to look at the many new products on display.

To guard against this kind of absent-mindedness (usually induced by the sight of a stunning blonde), the advertising people have developed what might be called mesmerized mannequins. Instead of just standing around in the booth, the girls now recite a memorized, semi-technical description of the products on display. Some wave a magic wand during their speech, others accompany their remarks with hand gestures suggestive of a Burmese temple dancer. The performance is pleasant to watch, but when all is said and done, the inquiring engineer often goes away disappointed, his specific technical questions unanswered.

I think the Royalite Div. of U. S. Rubber Co. has come up with the ideal combination. At the recent Design Engineering Show they had in attendance at their booth a young lady who is not only pretty and charming but also technically competent. Having had seven years experience in the company's physical testing lab, she was able to answer most of the technical questions asked of her. Needless to say, that booth was one of the best attended at the Show.



New Ameripol Micro-Black promises up to 15% longer tire wear

Automobile tires now have a new lease on life, thanks to Goodrich-Gulf's new high-dispersion masterbatch—Ameripol Micro-Black. Already, many leading brands of tires are made with it.

New Ameripol Micro-Black promises up to 15% longer tread wear in tires. That's because it is reinforced with micron-sized particles of carbon black thoroughly dispersed in the rubber by an exclusive process—high liquid shear agitation at the latex stage. Result? Tires and other products made with Micro-Black have controlled uniformity, superior dispersion, greater abrasion resistance.

But that's not all. When you use Micro-Black, you eliminate the weighing, milling, storage and mess of carbon black because it is already integral with the masterbatch. Because Micro-Black is shipped bareback, you also eliminate bag stripping and disposal costs. What's more, you can choose from *nine* high-dispersion types of Micro-Black.

With plants at Port Neches, Texas, and Institute, West Virginia, Goodrich-Gulf has the world's largest production capacity for synthetic rubber. For information on Ameripol Micro-Black, write for new illustrated Micro-Black data book, just off the press.

Goodrich-Gulf Chemicals, Inc.

3121 Euclid Avenue, Cleveland 15, Ohio

For more information, turn to Reader Service card, circle No. 499

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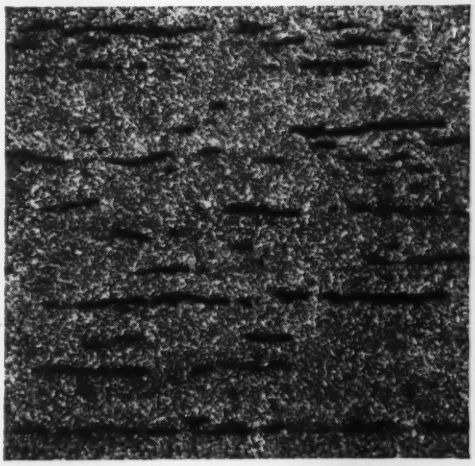
You get a steel that wears longer when you use Graph-Mo®. Reports from users show that Graph-Mo outwears ordinary tool steels 3 to 1! That's because of the combination of free graphite particles and diamond hard carbides in the Graph-Mo structure. You can see them in the photomicrograph at right.



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You get a steel that keeps gages and dies accurate longer when you use Graph-Mo. Tests prove its stability. For example, a typical master plug gage (see photo, right) made of Graph-Mo showed less than 10 millionths of an inch change after 12 years of use. Graph-Mo is the most stable gage steel ever made.

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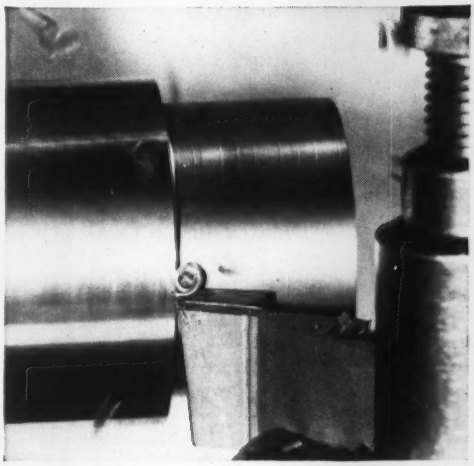
You save machining time with Graph-Mo. It out-performs ordinary tool steels on the Constant Pressure Machinability Tests. Graph-Mo machines 30% easier. Notice short chips in the photo at right. The free graphite in its structure enables you to make tool steel parts faster. Yet with all its advantages, *Graph-Mo costs no more than other oil hardening tool steels.* For time-and-money-savings, better finished products, specify Graph-Mo. There's only one Graph-Mo, and the Timken Company makes it. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*



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